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Tectonophysics

Sign Plate tectonics (Propagating Rifts)
GLORIA CRESHITIONS OF THE PROPADATING RIFT AT
93.5°W ON THE COOSS-MAZCA SEREDING CERTRE
R. C. Searls (Rapine Physical Laboratory of the
Soripps Institution of Commongraphy, La Jolia, GA
92093), R. M. Hey
In this paper we descipe a Gloria long-range
sideacan sours survey of the area ground 95.5°W on the
Cocoss-Maxca Rise where a propagating rift has been
predicted to occur. The sonar images clearly show a
wedge of new creat which is propagating into the 1-Me
eld cruat survounding it. The new cruat is up to 800 h
despar than the surrounding searfloor, elthough the
alevation difference appears to decay with time. The
"pseudofamits" which bound this new cruat have been
chearved from the rifft tip back to crustal locohron
0.65 Ma. Mear the rift tip they consist of scarpe
several hundred metres high with marrow, shallow
valleys at their feet. The "shaared zons" between the
southern pseudofamit and the trace of the failed rift
to the south is characterized by absorbally shallow

formed at the dying rift, perhaps accompanied by other deformation.

The youngest testenic and volganic lineaments on both operating segments atrike 273°, but on the dying rift short apressing segments are offset an echelon so that the regional trend of the rice axis is 265°. Older lineaments throughout the area strike 265°. The propagabing rift is thus replacing an oblique rise axis by one which is orthogonal to the spreading direction, and it is suggested that this is occurring in response to a recent change in spreading direction from 355° to 35°. Variations is the strikes of the pseudofults indicate that the propagation direction has varied, but that the rift has propagated most rapidly when following the 273° direction which we take to be normal to the new apreading direction. (Propagating rift, Corrier and propagation directions)

Vol. 64, No. 25, Pages 417-424

University, West Lafayatto, Indiana, A907. Available measurement of addinant wholists durally indicate that a factor of 600 minus; meroud of twe-way acditions reflection the climation depth to yield beasement depth in the of Budinent loading. This simple linear relatived from the results of six deep drill bed alvanual nuclibrants of the North and Sauth Alexandral available and the country of about 50 m, regardless of ilthology amapled, down to a depth of 1.1 s dilithology amapled, down to a depth of 1.5 s dilithology amapled, down to a depth of 1.5 s dilithology amapled, down to a depth of 1.5 s dilithology amapled, down to a depth of 1.5 s dilithology amapled, down to a depth of 1.5 s dilithology amapled, down to a depth of 1.5 s dilithology amapled, down to a depth of 1.5 s dilithology amapled, down to a depth of 1.5 s dilithology amapled, down to a depth of 1.5 s dilithology amapled, down to a depth of 1.5 s dilithology amapled to 1.5 s dilithology amapled and 1.5 s dilithology

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vetton of the Surface Circulation in a Gulf Stream Frontal Perturbation (Paper 3L0835)

Fred M. Vuktorich and George A. Mark.

Water-Saurated ion of Ultrasonic Attenuation and Fluid Permeability in Very Low Perosity Wal Raparimental Shock Lithification of Water Sharing Rock Powders (Paper 31.0561)

G. C. Allen, M. J. Jerchovic, T. See, K. Kell, S. W. Kleffer, and C.H. Sharing Rock Powders (Paper 31.0561)

A Climate Hypothesis Describing the Solar-Terrestrial System as a Frequency Domain With Specific Response Characteristics

Douglas A. Paine

The evidence for and against solar variability influencing weather and climate is beset by conflicting results (e.g., see Goldberg, 1982). This anide will examine a new point of departure that is designed to complement simple cause-and-effect methodologies. The study is laused upon an analogue to contemporary quantum

Individual atoms are known to exhibit discrete absorption and emission responses to oming radiation. John Jacob Balmer's 1885 description of the visible lines in the hydrogen spectrum was soon extended by Lyman and Humphreys to include both the ulraviolet and infrared components defining the simplest atomic element. In the late 1970's Édecided to test a climate concept based upon the known variability of incoming UV radiation and outgoing infrared that also displays a similar discrete frequency remonse. This response is primarily controlled by the triatomic molecules of O3, H2O, and CO2 that exist as diabatically important trace gases within earth's atmosphere.

The experiment produced its most notable success in predicting the 1981-1982 winter temperature departures evaluated by a power spectral technique [Paine, 1982]. These reills were promptly followed by a speciacular failure this past winter when errors of up to 16 °F between the observed and the expected departures were registered over the Midwest.

The elapsed time between these two results gave ample opportunity for speculating upon why the complexity of climate might be well suited to the worldview offered by quantum theory. Both the success and the failure focus on the postulated importance of significant changes of atmospheric stability by diabatic processes that is in keeping with the emphasis Planck had the insight to avoid a detailed derovided by Max Planck in 1900. Specifically, uniption of the diverse phenomena associated with electromagnetic physics. He strove insead for a single mathematical statement that would describe how a simple harmonic oscil-ktor was excited or damped by changes in the stability of its surrounding environment. doing so, he accomplished a unifying radiation law that was able to accommodate not only long (e.g., infrared) and short wavelengths (cosmic through X rays), but ultravio-let frequencies that appear to trigger impor-tant changes in both the biological and the

Tropospheric-Stratospheric Stability

Our discussion begins with the documenta tion of stability changes linked to the onset of a major drought. I have always been curious about a discrepancy that first came to my atention in the mid-1960's: namely, preparation of temperature-height profiles for the U.S. Extension to the ICAO Standard Atmosphere (Figure 1) revealed some significant differences between data gathered in 1954 versus that compiled in 1962. The 1954 anding profile came during a sunspot minimum, and it depicted an isothermal lapse rate above the tropopause boundary to near 25 km; the 1962 profile showed a more confined isothermal lapse rate (10-20 km), while a modest thermal inversion was found in the 20- to 30-km layer. Rocketsondes confirmed that a strong inversion from 10 mbar (30 km) to 1 mbar (48 km) reflected maximal diabatic g owing to oxygen photodisassociation that increased toward the stratopause bound-

Such a discrepancy might have easily assed unnoticed, except that much of the Northeast experienced its worst drought of tecord from 1960–1966. Namias [1966] had shown that the driest period, as depicted in Figure 2a, was paralleled by abnormally cold continental shelfwater from 1963–1966. He used this anomaly to argue effectively that the chilling of the lower tropospheric column tould be expected to enhance the static stabil-

Douglas A. Paine is an stociate Professor of Biomeleorology at Cornell University's College of Ag-riculture and Life Sciences, Ithuca, New York. He holds an M.S. in melearology from the Pennsylvania State University and a Ph.D. in almospheric sciences from the State University of New York at Albany. His research and leaching interests span the prediction of severe local storms to mechanisms of climate change, including the possible influence of climate stress upon evolu-

ity and thus decrease the vigor of precipita-tion events over the northeastern United

The 1962 temperature-height diagnosis of detectably greater stratospheric stability, commencing near 20 km, suggested that a kind of resonance in enhanced stability in both the lower tropospheric and the stratospheric regimes may have contributed to the drought situation. Was it, therefore, only coincidental that the more stable profile in 1962 came only 4 years after the strongest sunspot maximum of record (200 sunspots), as monitored during the International Geophysical Year

Likewise, the recent 1980-1982 composite of accumulated precipitation departures shown in Figure 2b, with its notable deficits to the lee of the Appalachian Mountains, follows closely after the second strongest (yearly) sunspot maximum of record. The excessive incoming ultraviolet, peaking near December 1979 as shown in Figure 3, would be expected to enhance the diabatic release of heat (142 | mol - 1 °K - 1) associated with ozone production in the middle to upper stratosphere. The consequent downward diffusion of this heat could have conceivably strengthened the positive lower stratospheric lapse rate until 1987. (The forward phase shift in the 'solarinduced' stable mode shown in Figure 3 represents an idealized schematic. It is meant to account for the clapsed time of 2 or 3 years. that would be required before the diffusion process significantly reduces the depth of the sothermal lapse rate.)

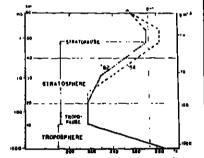


Fig. 1. Temperature height profiles to 60 km for the U.S. Standard Atmosphere depicting the 1954 versus 1962 observed differences in stratospheric lapse rates above 20 km.

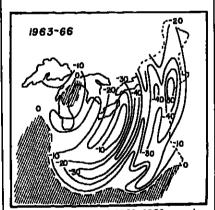


Fig. 2a. Observed 1963-1966 cumula tive precipitation deficits. Isopleth interval equals 10 inches (254 mm). Maximum 1960-1962 cumulative deficits of 20 inches were confined to a narrow corridor extending from Concord, N.H., to Bridge-



Fig. 2b. Observed 1980-1982 cumulative precipitation departures relative to 30-year mean. Isopleths labeled in inches; dashed lines and shading represent excesses, solid lines designate deficits. Sources include 1980–1981 Local Climato logical Data (National Climate Center) and 1982 (preliminary data) published in the Weekly Weather and Crop Bulletin (NOAA/USDA Joint Agricultural Weather

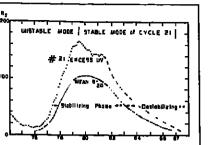


Fig. 3. Solar cycle 21 compared to mean of cycles 8-20. Mean monthly sunspot values (R₂) from Solar-Geophysical Data, U.S. Department of Commerce, Boulder, Colo. Date marks indicate June of each year; cycle 21 began June 1976 and is projected to end June 1987.

However, the April 1982 eruption of El Chichon added additional complexity to the situation. The volcanic debris' observed reinforcement of lower stratospheric warming coming in phase with the quasi-blennial oscil lation (QBO) may have been strong enough to override the expected trend in the East to-ward enhanced stability well above the tropopause. Parker and Brownscombe [1983] reported a +6°K (+3\sigma) was ming at 30 rubar over equatorial latitudes, a situation that actually may have reversed the expected positive temperature gradient above 24 km. Either way, he phasing of the positive temperature trend nduced by QBO-El Chichon working in consort to after the lower stratospheric stability. or the compled role of enhanced stability inferred from 1960 to 1966, directs our attention to the manner in which diverse energy. sources are able to reinforce or to cancel one

On the Importance of Resonance

At the end of the severely cold 1976-1978 winters, my interest in the physics of climate grew when a Cornell colleague showed me a series of curves like that depicted in Figure 4 As New York's climatologist, Boyd Pack had been plotting the 20-year running averages of winter seasoned temperatures, utilizing data extending back to 1892. These curves indicated that the recent period over the interior Northeast has been cooler than any previous decade in the 20th century.

A careful inspection of the December-February running averages revealed a notable ac-celeration of longterm warming (1923, 1933) and delay in time-averaged cooling (1954, 1965, 1976) near the onset of five out of seven sunspot minima (1). Two questions came to mind as 1 studied these curves: (1) What could give the temperature graph the appearance of the output generated by a thermal ca-pacitor that slowly 'discharges' to reflect di-minished heat input during one phase (maximum to minimum) of the solar cycle? (2) What could then cause this same thermal capacitor to 're-charge' vigorously (or entrain heat) beginning around sunspot minima? The answers might involve the tendency for cold air masses spilling southeastward from Canada to extract considerable latent and sensible heat from the Great Lakes or the nearby warm waters of the Gulf Stream. If so, then the geographical dimensions of these heat storage areas would present the potential for resonant interactivity between solar, atmospheric, and even hydrospheric energy

From the quantum viewpoint, we can en-Lakes exhibit natural harmonics in relationship to the 11.2-year periodicity of the sunspot cycle, just as this cycle is itself a harmonic of the 90-year Gleissberg cycle [Agee, 1980]. The large-amplitude patterning of the pre-cipitation deficits shown in Figure 2a—looking very much like a 'standing-wave' config-uration excited over and amplifying to the lee

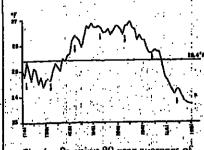


Fig. 4. Running 20-year averages of winter season (Dec.-Feb.) temperatures (F) in the Finger Lakes region of central New York, Length of data record: 1802-1983. Arrows indicate timing of observed

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of the Great Lakes—suggests this simplifying concept is applicable to the physics of climate Nested primitive equation modeling of classic lake-effect snowstorms by using moist diabatic physics [Kaplan and Paine, 1973] had earlier revealed an overlooked subtlety in the dynamics of vigorous air-sea exchange: that is, not only does it require relatively cold flow down the length of the longest lake fetch, but the triggering atmospheric wave generates the largest response when the dimensions of the energy source or heat reservoir represent some harmonic of this wavelength.

Climate Complexity and the Laplace Transform

Just prior to the unprecedented 1978-1979 winter with its severely cold departures across the entire contiguous United States (Diaz. 1980], Figure 5 was constructed from the observed cooling pattern exhibited since 1950 and was recently updated and extended to the expected timing of the next sunspot mini mum in 1987. The mathematical formalism used to generate and interpret this curve is based upon a systematic and elegant procedure widely used in the study of feedback and control. The complexity of climate built upon forcing functions ranging over a vast variety of time scales seems particularly suited to this form of analysis because it requires. knowing only the governing periodicities and response amplitudes characteristic of the dynamical system. (The 11.2- and 90-year sunspot cycles, plus the commonly observed range of winter averages in the Northeast spanning ±7°F (7°C)—or 0.7°F on the 20-year running average scale—set the necessary parameters in Figure 5.) In this treatment, one is asked to imagine a solar-terrestrial feircoir composed of diabatic energy capacitors, inductors, and resistors that are combined until one reaches a desired outcome replicating the behavior of the physical system at hand. The reader is referred to the appendix or Sokolorkoff and Redheffer [1966] for a more detailed elaboration.

The top right-hand corner of Figure 5 de picts the resultant Laplace transform of an 11.2-year periodicity drawn over three solar cycles, after first neglecting the superposed longterm periodicity from 1954–1987. The curve at the bottom of Figure 5 shows how the minima of observed Zurich sunspot numbers for cycles 18-21 captures the ensemble effect of enhanced heat entrainment commencing with 1954, 1965, 1976, and 1987. The latter year is the projected timing of the next sunspot minimum as documented in

Figure 3 and Lincoln [1979]. The value in formulating this background trace is that it provides a quantitative point of reference for 'reading' either gradual departures from the idealized trace—like the recent flattening of the projected cooling trend in the 1980's—or the sharp departure associated with the 1982-1983 winter. In the former case, the particularly unsteady profile prior to 1920, and the flattened peak associated with the relatively warm winters in the 1940's, indicates that greater heat exchange fluctuations may prevail near the long-term winter temperature extrema. The recent 1982-1983 winter anomaly may therefore represent a return to a similar period of greater year-toyear uncertainty about seasonal departures. It is also interesting to speculate whether the 1983–1984 value for the 20-year running av-

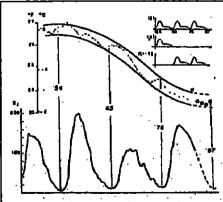


Fig. 5. Observed and projected 20-year running averages, (°F, °C) for winter season in central New York. Upper righthand inset depicts Laplace functions (see appendix) fit to the 11-year sunspot cycle. years of minima as indicated. Zurich sunspot numbers (R_s) plotted at lower portion of diagram illustrate the observed (and 1987 projected) reversal in the long-term cooling trend at sunspot minima. Warm anomaly (cross) registered in 1982-1983 winter yielded a + 10°F error in expected seasonal average based upon solar UV modulation (i.e., 29.4°F observed versus 19°F projected).

erage will return toward the previous extrapolated value or remain near the new plateau ostabilished by lost pictor's appropries

established by last winter's anomaly. A 'climate circuit' designed around the Laplace technique can easily include either a periodic QBO effect or a single-incident component like that of a strong volcanic event. Furthermore, the inferred alteration of stratospheric stability by El Chichon's sulfuric acid haze layer emphasizes the important role of anomalous albedo duration at any atmospheric level. For instance, the record length f snowcover throughout the Northeast in the 1977-1978 winters [see Dewey and Heim, Jr., 1982] had earlier suggested the need for adding an 'enhanced albedo' component to the mathematical circuit to account for lower tropospheric chilling. This cooling dropped the observed winter averages 2°F below the expected solar-induced departure, while the absence of an effective snowcover albedo this past winter may have contributed up to onethird of the +6°F departure (relative to the 30-yr mean) observed over western New

Direct Versus Indirect Solar Signals

Currie [1979] published evidence of a solar signal in surface air temperature over North America utilizing the maximum entropy method (MEM) of spectral analysis. The largest amplitude of the observed 10.7-year signal (0.9°C) was found over the Northeast. The depressed thermal peaks near the time of sunspot maxima led many investigators to postulate a direct sonspot-climate link; that is, the dark umbra/penumbra distinguishing sunspots have long been thought to reduce the net solar output by a few tenths of 1% [see Hoyt, 1979].

The indirect mechanism of ultraviolet control over diabatic heating of the troposphere by modulation of major storminess—enhanced from sunspot minimum-to-maximum-which is postulated here does share one thing in common with Currie's result. The inferred sunspot signals in both studies weakened toward the far South and were effectively absent to the west of the Continental Divide. In fact, this investigator found substantial differences in the 20-year running av erage curves across the 600-km length of New York state, seemingly dependent upon the proximity of the five regional profiles (averaging 12 stations per sector) to lakes Erie and Ontario. These differences appear to argue in favor of the importance of in situ dia-batic heat sources in generating the idealized (indirect) 11-year signal, while latitudinal or continental dependency (direct solar heating and bulk heat transport) would help to shape such long-term references as the 90-year winter means of 25.4°F versus 18.7°F in central New York and the St. Lawrence Valley Region, respectively.

More recently, an 11-year thermal signal has been confirmed over northern Europe yet is notably absent over central Asia (see Kerr, 1982). These equally meaningful null results obtained over certain portions of the globe, and not others, may be tied together by a common dynamical thread. For instance, the lack of a detectable 11-year signal on this continent occurs next to the cold upwelling of Pacific water along the West Coast. In central Asia, or Canada's Hudson Bay region, warm surface waters are essentially unavailable for heat transfer in winter because of their outright geographical absence or substantial ow and ice cover. I refer to such regions as diabatically dormant' portions of the globe, just as other areas and atmospheric levels are qualified as 'active.'

In the case of the far South (below 35°N), the cold air intrusions over the warm Gulf of Mexico are more sporadic from winter-to-winter than at the latitude of the Great Lakes (40°-45°N). The southern intrusions often produce the most effective atmospheric heat realization when latent heating is maximized farther north over the eastern United States, a process that requires major macrocyclogenesis and its embedded vigorous convection to reach peak efficiency.

Role of Intense Convection in Coupled Dynamical Studies

Before attempting to relate how UV modulation of stratospheric stability might help to account for a solar-induced thermal signal. I feel it is important to explore the possibility that the hydrological cycle and the observed discharge of a major northeastern river may be linked to the 11-year cycle. This will lend added credibility to the postulated importance of latent heat release, since only convective storms can approach the 100% efficient conversion of water vapor into condensate. In contrast, macroscale uplift in winter cyclones absent convection is only about one tenth as efficient in precipitation production. We will also want to document that riggered convective activity in both the atmospheric and the confinental shelfwater regimes has a crucial self-regulating role to play in maintaining the vigor of biospheric activity.

Figure 6a depicts the result of applying MEM to the 1900-1970 time series of the river of the series of the river depicts of the river

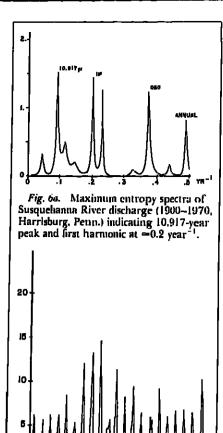


Fig. 6b. Predicted mean monthly discharge (1971–1991) in ft³ s⁻¹. Both figures adapted with permission from May [1981].

vania, centered within the Susquehanna watershed. This 27,500 mi² drainage basin has only limited man-made modification above Harrisburg, and ranks as the largest such basin in the Eastern United States. The Susquehanna River is situated midway between the eastern Great Lakes and the mean location of the Gulf of Mexico stormtrack that runs between the Gulf Stream and the Appalachians. May [1981] found a 10,917-year periodicity and its first harmonic, as well as a possible reflection of the QBO. The same technique applied to the mean yearly sunspot number (1900–1970) revealed a 10,549-year power spectral peak, including its two harmonics at 5,280 and 3,495 years.

A prediction model described in May's M.S. thesis is an autoregressive or feedback system where 300 coefficient involve one-half the data length. The 1950–1970 test prediction from the 1900–1950 time series showed that individual 'flood' or 'drought' years were not necessarily captured by MEM; however, the 5-year composite of the integrated discharge was more skillfully represented. As a recent example, the 1971–1991 prediction shown in Figure 6b missed the excessive precipitation year of 1972 which included Hurricane Agnes and runoff from heavy winter snows generated by a major Nor'easter, but the outlook captured some of the record wetness in the late 1970's followed by the very dry beginning to the 1980's.

Embedded in this predicted period is the so-called New Jersey anoxia (oxygen-depletion) incident involving large kills of shellfish in the New York Bight region during the summer of 1976. This is the same year a similar anoxic condition of El Niño last occurred off Peru, prior to its 1982-1983 return that covered a record eight million square miles of the equatorial Pacific. (Although the 1975– 1976 winter was also labeled of 'anomalous' character over North America, the first 2 months of that winter were distinguished by sharp cold over the East, as opposed to the record warmth that began the 1982-1983 winter. The detailed comparison between these two winters suggests care must always be exercised when assessing the relationship between +10°F departures over the northcentral United States and unusually warm Pacific water in the tropics. For instance, repeated cold outflows from Siberia maintained an unusually large and intense Alcutian low over the Gulf of Alaska, representing a very efficient sensible and latent heat pump near 60°N Intitude [see Wiin-Nielsen, 1982]. However, it is true that the more modest 1975— 1976 El Niño was marked by +4° to +6°F de-

partures over the Northern Plains.)
In assessing possible authropogenic (toxic waste dumping) versus environmental factors that may have contributed to the 1976 oxygen-depletion incident, I will quote from a summary by Alosers [1978]. It began by relating shelfwater biological activity to horizontal kinetic energy profiles examined along the eastern seaboard. Both zooplankton and phytoplankton, plus fish, are associated with spectral density peaks in the frequency distribution that describes barotropic and baroclinic (storm) disturbances in this domain, as well as annual, diurnal, and intertidal cycles.

After a severely cold December and January, there was an early spring. Authorspheric warming produced thermal atratification phis anownel; and river typioff and thus, aligns and springed density.

stratification about a month earlier than normal. An intense and persistent bloom of Ceratium tribos in the region may have been 'supported' by this intense density stratification; its eventual decomposition could be expected to contribute to [a] reduction of the dissolved oxygen concentration in the lower layer. [Upper and lower layers are with respect to the thermocline, while 'supported' is a double entendre: (1) The strong density stratification physically supported the Ceratium;
(2) it provided a physical niche they could exploit and monopolize to outcompete other phytoplankton for light and nutrients.) The anomalously early stratification obviously eliminated ventilation of the lower layer by free convection. Associated with the early atmospheric warming was an early cessation of the wintertime weather cycle of vigorous cold fronts and evelones. This could be expected to reduce the amount of forced convection produced by wind stirring of the upper layer. Other factors came into play with a shift of the weather cycle. In early summer, a several-week period of weak but persistent winds with a poleward component occurred off New Jersey, driving coastal upwelling. Associated with the upwelling was an onwelling (on-shore flow of lower layer water) of mutrient-rich and oxygenated water from the outer to the inner shelf. During this period, the dissolved oxygen concentration in the lower layer decreased at an anomalous high rate and reached a level much lower than the usual late-summer mini-

Of special interest are the inferred roles of 'free' versus 'forced' convection in this incident. In the ocean, free convection is overturning due to negative buoyancy induced by cooling or evaporation at the sea surface. Forced convection refers to mechanical stirring due to wind-generated waves and turbulence in the upper layer, or tidal motion stirring the bottom layer. Helping to resolve the anoxia condition in late summer was Hurricane Belle which passed over the region as a small, swiftly moving, spiral-banded convec-tive system with 93 mph squalls. Again, quoring from Mooers: 'This hurricane generated vigorous inertial oscillations and some wind stirring, but it did not overturn the water column . . . the stratification quickly "healed," leaving the ventilation of the lower layer to the normal autumnal cooling."

Students of meteorology sometimes create an effective analogue to atmospheric convection in fluid tanks by injecting a 'milky' saline solution from a syringe into clear water, then videotaping the event with a corners mounted upsidedown. By scale similardo of the wn. By scale similitude of the Froude number—or the ratio of the kinetic to potential energy characterizing a turbulent event-the final inverted image of the saline plume looks a great deal like the mixing of cloudy and clear air surrounding positive buoyancy accompanying a cumulonimbus. (A I°C temperature excess in the cloud yields a buoyancy factor of 5×10^{-3} which can be easily matched by the saline mixture to give identical Froude numbers of 2×10^{-2} .) If the vertical mixing of life-supporting mutrients and oxygen is aided by storm-generated convection, is there a similar mechanism that ght explain how macroscale cyclogenesis with its vigorous embedded convection is aided and abetted by solar modulation of incom-

Solar-Terrestrial Connection

Major storms with central pressures of less than 1000 mbar (100 kPa) are invariably accompanied by a break in the tropopause boundary which serves to separate the stratopheric and tropospheric regimes. (The height of the troposphere, globally averaging between 10 and 16 km, has been observed to oscillate by 0.5 km with an 11-year periodicity over the equatorial Pacific, peaking near sunspot maxima. This study by Gage and Reid [1981] was limited to data obtained from two radiosonde stations, the time series itself being restricted to two solar cycles. It would be resting to perform a spectral analysis of the varying thermocline depth-the ocean's analogue to the tropopause—provided a more suitable time series was available.)

A tropopause break and its attendant fron-tal discontinuity (thermal inversion) enrich the troposphere with storm-producing cyclonic spin by creating the downward transport of stratospheric air. Such air is characterized by large magnitudes of positive potential vorticity or potential cyclonic spin once the atmospheric column in question is destabilized by diabatic heating at its base. Storms of this intensity are also found to enhance the planetary boundary layer's upward flux of sensible and latent heat by 1-2 orders of magnitude. The sunspot component of the quantum climate hypothesis effectively asks whether or not such incidents of tropopause folding and breaking are somehow augmented when a lessening of the incoming UV ra-diation results in significant episodes of lower stratospheric destabilization.

Unlike the positive buoyancy excited by the input of diabatic hear at the base of a troposplution polyment these oceaning of strate-

tached to incidents of negative buoyancy air that descends because it is colder hand surrounding environment. The fartheneds scent of negatively buoyant air would one when the Ordiabatic heat source and subsequent downward diffusion of heat had due is shed, effectively replacing the modest increase in the modest in with an isothermal lapse rate below 27 km. Such episodes of intense subsidence, disguished by their descent of large positive a triggered by the momentum deposition as triggered by the momentum deposition as ing from vertically propagating, intenal gravity waves. These acoustically modified waves often originate in the tropperson.

spheric instability would most likely be

guished by their descent of large positives uses of potential vorticity, are most likely at triggered by the momentum deposition asing from vertically propagating, internal gravity waves. These acoustically modified waves often originate in the troposphere wherever strongly sheared flow is found crossing undulating terrain [Jones and Haughton, 1971], as well as arising near they stream core within so-called "jet streak" goducing wave-induced (Kelvin-Helmhola) at bulence.

bulence.
The capability of vertically propagating waves to produce narrow zones of momentum deposition wherever the wave trace to locity encounters a background flow of equimagnitude is usually met at the level of the sharp transition in the lower stratospheric lapse rates. The momentum surges created this level of deposition are capable of displaing relatively cold layers which then overify warmer air, commencing the descent of the denser volume with its large potential void ty toward the tropopause. This investigated has found that the above sequence of each typically precedes tropopause rupture by 6-12 hours [Paine and Kuplan, 1974].

The critical climate control of more fre ient cyclogenesis in the troposphere ov therefore be exerted by simply providing through UV modulation a deeper isoth lapse rate in the lower stratosphere. (The li Chichon-QBO destabilization of this same zone is likewise postulated to have overwhelmed the current solar-induced lender toward stabilization, perhaps even creating volumes with an uncharacteristic temperature. decrease with height near 25 km to promo even more frequent macrocyclogenesis.) Equally vigorous packets of upward-propgating, internal gravity waves could only duce negatively buoyant plumes capable of reaching the tropopause boundary in the of an isothermal (or even less stable) envir ment prevailing from 20 to 27 km. A mode inversion dominating at these levels would mitigate against high potential vorticity p from ever reaching the troposphere. In the regard, it would be interesting to compare mean stratospheric lapse rates prevail during the very dry 1980-1981 episode be affected much of the contiguous United

States, versus the more recent excessiely so period (1982–1983). Normally, additional UV radiation accompanying strong sunspot maxima would be o pected to maintain a modest inversion from 20 to 30 km, as in 1962. This stable mode hypothesized to lead to a decrease in the number of exchanges across the tropopaut boundary of downward flowing high pote tial vorticity pools, with a consequent decrease of air-sea interactivity tied to less for quent and intense major storm develop over warm water source regions. Seen in the way, the sudden reversal in the cooling in frequenting sunspot minima, as shown in his tires 4 and 5, represents a type of dynamic discharge that begins to release an increase number of potential cyclonic spin "packet" (negatively buoyant plumes) built up during the stabilizing phase of the H-year solar o-

S ISBN 0-87590-2065 Climatic Changes

M.I. Budyko

English Trans., R. Zolina

English Trans., editor, L. Levin (1977)

The application of physical digita.

tology in studying climatic changes is the main problem presented in this book.

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Analogue to Planck's

The extreme sensitivity of tropospheric cyclogenesis to the depth of the stratospheric isothermal layer becomes more understandable when we consider that potential vorticity typically increases from 200 to 20,000 units (x10⁻¹⁰ cm s °K⁻¹) between the height of the tropopause boundary to 30 km. Thus, the difference of only a few kilometers in the added height of this layer can easily make available a substantial increase in the positive potential vorticity inherent in the negatively

Ertel's [1942] potential vorticity theorem composed of a synthesis of the conservation laws for mass, momentum, and energy in a ingle mathematical statement—has received wide application in diverse dynamical studies ranging from oceanographic to ionospheric. for our purposes, where we are attempting o synthesize into a single mathematical statement the exchange of information among many dynamical regimes, it is instructive to consider that potential vorticity is closely aligned to the concept of angular momentum. Each volley of upward-propagating internal gravity waves that serves to dislodge a negatively buoyant plume of high potentia runicity is thus creating a discrete "packet" of cyclonic angular momentum capable of significantly influencing tropospheric dynamics. This unifying concept brings us full circle,

This unifying concept brings us full circle, back to Planck's discovery of the quantum nature of radiation and Schrödinger's wave equation that describes the exchange of angular momentum among complex systems. As was mentioned in the introduction, Planck began his derivation with an equation descriptive of a simple harmonic oscillator. Although the oscillating element was originally conceived of as an electron embedded in an electromagnetic field, contemporary physicists emphasize that different sets of elementary particles represent varying "resonance channels" or patterns of quantum connections.

Not only is this mathematical format appealing when it comes to describing the com-



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Cover. Auroral imagery from the DMSP-F6 satellite. The two photographs are from the DMSP Optical Linescan System, taken on consecutive northern hemisphere polar passes on January 18, 1983. The dawn aurora is in the lower part of the photos, with midnight to the left and dusk at the top. The overlayed contours show bremsstrahlung X ray intensity measured by the scanning SSB/A X ray sensor provided by The Aerospace Corporation's Space Sciences Laboratories. (See Eas, p. 170, May 3, 1983.) (Photo courtesy D. J. Gorney, P. F. Mizera, and W. A. Kolasinski,)

plexity of the solar-biospheric-climate gestalt, but even the interim idea put forth by Bohr that an atom consists of discrete energy levels seems relevant to the highly interactive atmospheric and oceanographic domains. However, what constitutes an "electron" in the present study.

If we recall that "sunspots" consist of intense convective disturbances in the solar atmosphere, then the ubiquitous nature of convective processes in all dynamical domains reminds us that they alone can change the identity of a system at its most fundamental level. The atmospheric analogue for an equation describing a simple harmonic oscillator:

$$\ddot{\tau} + \frac{f(S)}{\rho G_0} \dot{\tau} + \frac{g}{T_0} (\gamma_d - \gamma) \tau = 0 \tag{1}$$

states that the zeroth, first, and second-order time derivatives of τ —or the temperature difference realized in a convective event which is 100% efficient in creating condensate—forms the mathematical basis for describing super-efficient information exchange within atmospheric dynamics. In addition to the diabatic or quantum signal represented by τ , other variables in (1) include the density and temperature (ρ , T_e), the gravitational acceleration (g), the dry adiabatic and environmental lapse rates (γ_d , γ), and the specific heat at constant pressure (G_p). The term f(S) refers to the position of the buoyant parcel relative to its initial entropy state, where the parcel's change of entropy is dependent upon its change of potential temperature, and G_p .

If the coefficient of \(\tau \) is negative, then the buoyant parcel will be dislodged from its original constant entropy level; if positive (stable case), the parcel will oscillate about its original position at a frequency given by

$$\nu = [(g/T_c) (\gamma_d - \gamma)]^{1/2} / 2\pi$$

Like Planck, we use a change of entropy plus specific frequencies to define information exchange among macroquantum domains. We thus avoid a spatial description of the hydrothermodynamic field by simply noting how an elemental oscillator (convective event) behaves when embedded in a field characterized by a particular stability. This amounts to saving that the convective event is a discrete element of radiative flux which obeys Stefan-Boltzman's law for a blackbody [see Pance and Prusinger, 1979].

We have been addressing the negatively buoyant, stratospheric phenomena in much of the above discussion. Let us now shift our attention toward the equally important, positively buoyant (tropospheric) events that accompany the macroquantum information exchange process. The atmospheric analogue to Planck's law descriptive of the energy (U) of the radiant fields states

$$U = \frac{h^* v}{e^{h^* v/C_P T} - 1}$$

This analogue substitutes C_n for k (Boltzman' constant), while the tropospheric value for Planck's constant (h*) has empirically been found to equal 21 × 1010 erg s. (The energy (E) which may be dislodged from a discrete layer whose potential is defined by h* is determined by a specific frequency of oscillation (v).) In a severe convective storm generating internal gravity waves, a typical ratio for the exponent (h^*v/C_pT) is 0.025, where the scale height of the troposphere (10 km) must be exceeded by the upward propagating waves to achieve information transfer. This height is effectively compared against the horizontal distance (400 km) of a "bowed" frontal inversion. Such a density discontinuity or interface serves as a wave guide for external gravity (or so-called "shallow-water") waves organizing coherent bands of severe convective activity.

The advantage of employing quantum physics to explain highly nonlinear, multiscaled information exchange between complex systems is its elegant simplicity: for example, satellite pictures may present a bewildering view of warm water eddies breaking away from the Gulf Stream or developing cumulonimbi in a thunderstorm ensemble that defy a detailed Newtonian-Cartesian solution. Yet the quantum approach tells us that the energy entering or leaving a limited domain must appear at a specified frequency (or its harmonics) uniquely determined by \(\gamma\), \(\gamma\)_d \(\rho\). and \(T\), if there is to be a fundamental change in the system's identity.

The quantum view of climate supports the concept first entertained in the context of the Laplace formalism: namely, warm water bodies function like "tuning forks" and thus are able to act as a colierent wave and energy source for the atmospheric medium, provided the appropriate multilevel stability criteria are met and the proper "hammer" is present. The 11.2-year sunapot cycle is apparently one such instrument where the interactivity with earth's heat reservoirs (including the O₃ layer) occasionally rings loud and clear in the physics of climate. Other possibilities come to mind; for example, the highly variable energy inputs associated with solar flares of cosmic ray emissions; all have the potential of exciting resonant states of activity at decipherable levels of the atmosphere when yiewed from the quantum paradigm.

viewed from the quantum paradigm.

Alternatively, El Chichon in the quantum world view appears much like a "high ener-

gy" dimate event whose rare cascade of coninuing interactivity may have had the abilic to dramatically alter one or more of the normal pathways that constitute the rich matrix of solar-terrestrial connectivity. After a short review of the postulated role of solar-modusited incoming UV radiation, we will address the question of mankind's ability to alter earth's climate via the absorption of outgoing infrared radiation by increased amounts of carbon dioxide. Once again, the quantum climate hypothesis is found to offer new insight for scientists seeking to gauge the influence of the ongoing exponential rise in the burning of lossil fucls or the effects of changing earth's albedo through the melting of sea ice or deforestation.

Conclusions: Factoring in the Influence of Mankind

A simple cause-and-effect concept of climate has assumed that the greater the solar input, the more beat will be available to the atmosphere. This is correct, provided one is careful to distinguish the particular level that s heated and also its ultimate effect. Because ultraviolet radiation represents only 14% of the net solar energy received by earth, most of which is absorbed above 16 km, its primany importance is one of controlling strato spheric stability. When there is greater incoming UV radiation, the enhanced production of ozone provides an important diabatic heat source to the stratosphere. This added stability, in turn, could conceivably suppress the number and intensity of major tropospheric storms unless overridden by other

Such storm suppression would effectively decrease the upward flow of sensible and latent heat into the lower atmosphere. Paradoxically, we therefore see that the net effect of greater UV radiation-heating only a small, but dynamically important portion of the weather-producing troposphere. (Alternatively, prolonged absence of sunspots, such as in the 17th century's Maunder Minimum or the earlier Sporer Minimum, could effectively exhaust many of the heat reservoirs by contributing to greater climate instability and storminess. Presumably such a dynamical sequence, as evaluated in oceanbed and icecores, would hist provide a "rush" of diabati heat input into the troposphere, followed by longer episodes of abnormal chilling.) The nonlinearity of the postulated triggering mechanism enables the slow buildup of stored solar energy arising from the net incoming radiation to be released over relatively short periods of time. This, in turn, yields a commensurately greater response factor to the physics of climate. From a biological perspective, large short-term thermal fluctuaions can also extract a severe evolutionary

The self-organizing and self-regulating capacity of the oceans, atmosphere, and biophere working in consort to maintain earth's life support system is receiving increasing attention. In keeping with James Lovelock's thesis examined in Gaia [Lovelock, 1979], I have chosen the intendisciplinary concern over COs buildup to illustrate burther how quantum climate physics accentuates the crucial roles being played by trace gases like Ox and CO₂. Ozone is subject to chemical sources and sinks (e.g., NO₄) that are them-selves subject to modification by anthropogenic activity; however, for brevity, the CO2 problem—although far from being "simple because it, too, changes in proportion to the varying backdrop of biospheric activity, ocean temperature, and circulation-will suffice to demonstrate another potential application of the quantum paradigm.

In prior discussion, we have stressed stability variations associated with the diabatic effects of water vapor, a rather "prolific" trace gas that constitutes anywhere from 0 to 4% of the troposphere by total volume. From 1958 to 1980, atmospheric carbon dioxide content has risen from 345 to 338 parts per million [MacGracken and Moses, 1982]. an increase of 8% in 22 years. The current scientific consensus estimates that CO2 may have increased by 25% since 1850 and is likely to double its 0.034% volume content before A.D. 2100. Additional CO₂ at the projected level of increase has the capacity to absorb greater amounts of the returning longwave radiation, creating the so-called "drafty" (or convectively influenced) greenhouse effect. Essentially linear models of climate have extrapolated that at least a 2°C global warming and consequent melting of polar scaling and rise of sea level could result from this effect within the next century.

However, the quantum climate hypothesis shifts our attention away from any linear or direct climate influence by asking a two-part question: First, how is mankind's release of solar energy stored in tossil fuels over geological time linked to the terrestrial mechanism of soring and releasing heat and CO2 within the hydrosphere? Second, and perhaps most importantly, is it possible that CO2-induced intraced absorption will exert an influence or climate primarily through alterations of stability rather than simple bulk beating? It this is so, it is crucial that we determine whether lower stratospheric stability—scenningly capable of being profoundly aftered over at least a short 2 or 3 year period by a single major. volcanic eruption—is subject to a longer term CO₂ influence.

In the emerging quantum view on the nature of climate, the sun-earth system appears like a symphony being played by a molitude of instruments. These instruments are defined against a widely varying backdrop of space and time, a fact that precludes a rigorous mathematical description of their interactivity when studied from the Newtonian paradigm. The quest of the climate theorist is not only to describe the individual instruments, but also to yield practical advice on how these components behave as a collective and highly complex system.

Article (cont. on p. 428)

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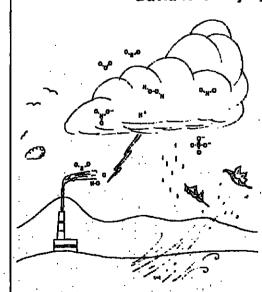
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Article (cont. from p. 427)

Appendix: The Laplace Transform

The basis of this method is the transformation defined by

$$F(t) = \int_{0}^{t} f(t)e^{-tt} dt = If \qquad (A1) \quad Acknowledgments$$

The function F(s) is the Laplace transform of f(t), and the operator L that transforms f into F is the Laplace transform operator. This formula represents a superposition of exponential functions, e^{-it} , where the superposition is over time t and v represents frequency.

To duplicate three solar cycles from 1954 to 1987, we begin with

$$\int_{0}^{\infty} e^{-tx + cu} f(t) dt = \int_{0}^{\infty} e^{-st} e^{-ct} f(t) dt$$

and note that this is equivalent to

 $F(s + c) = L[e^{-ct}f(t)]$

A property related to equation (A2) is

F(s) = L[f(t)]

 $L[f(t-e)] = e^{-ix} L[f(t)]$

where the constant $r \ge 0$ and f(t) = 0 for $t \le 1$ 0. Equation (A3) can be used to obtain the transform of an admissible periodic function f(t) of period T > 0. We can then state the in-

 $f(t) = f_0(t) + f(t - T)$ $t \ge 0$ (A4)

whose graphical interpretation is given in Fig-

This work is supported through U.S. Department of Agriculture Hatch Project NY(C) 125442. Many of the scale interactive concepts came about under NSF grant (GA-35250) and NASA contracts involving studies of severe local storm generation and numerial prediction. Joan Vyverberg Jensen aided in the preparation of the manuscript.

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Mount Narrayer in western Attstralia at 4.2 billion years, the oldest date of a terrestrial smple (New Scientist May 19, 1983). How these dates will stand up vis a vis the oldest whole-rock dates (3.8 billion years for samples from West Greenland) remains to be gen. The Mount Narrayer date is for single grains extracted from a sedimentary rock. The Greenland whole-rock dates were obtained by more conventional, though nonetheless state-of-the-art, mass-spectrometry

The concept of the ion microprobe probably dates back to the early 1940's RCA parents of J. Hillier. R. Costaining revived the ileas about electron and ion microprobes less than a decade later in his thesis research at the University of Paris, and he built prototype instruments. It has taken two to three decades since then for the promise of the ion microprobe to be realized. Quantitative isolope analysis of single crystal surfaces on a point-by-point basis may have far-reaching applications in broad fields of geophysics. scope ratios for age-dating purposes will be very powerful, as will isotope and trace-ele-

The new zircon dates are based on uranium and radio-decay product ratios. To be an accepted milestone in the studies of dating the earth, the rocks from which the zircon rysials were derived must be known. The unlication is that the zircons originated from rocks whose radio clocks were set 4.2 billion cars ago. Rather than a clearly documented geological observation, the new results are more in the form of a portent of things to come. Scientists will find it exciting when there is hard evidence that the earth is as old

The ion microprobe represents a combinaion of the complex technologies of electronon (static field) optics, surface-ion physics. and the intricacies of the mass spectrograph. t would appear evident that this combi sion and, indeed, of others who are pioneering this great advance.—PMB

IRAS Discovers Second Comet

Astronomers sifting through data sent to earth by the Infrared Astronomical Satellite (IRAS) have discovered an extremely faint comet that came within 210 million ker of our sun on January 20. This is the second comet to have been sighted by the satellite in atwo-week period.

Comet IRAS (1983F) was found by the orbring telescope on May 13 (GMT) and was firmed by ground-based observers on May 19. The comet is one million times fainter than comet IRAS-Araki-Alcock, which was discovered simultaneously by IRAS and the two amateur astronomers for whom the coma is named. IRAS-Araki-Alcock passed Earth

Many faint comers that had previously passed through the inner solar system without being noticed now may be able to be sighted by IRAS in its year-long sky survey.

RAS astronomers say.

IRAS is a joint project of the U.S. National ronautics and Space Administration, the Netherlands Space Agency, and the United Kingdom's Science and Engineering Research

Streamflows at Record Highs

Streamflow was reported well above average in more than half the country during May, with flows at or near record levels for the month in 22 states, according to the U.S. Geological Survey (USGS), Department of the

USGS hydrologists said that above average flow was reported at 98 of the 173 USGS key index gauging stations used in their monthly check on surface- and ground-water conditions. High flows were most prevalent in the Mississippi River basin states and in the cast. with the exception of Maine, South Carolina, and Georgia. Below-average streamflow occurred in the Pacific northwest and in small scattered areas in Colorado, Kansas, Texas, and Minnesota. The combined flow of the three largest riv-

ers in the lower 48 states-Mississippi, St. Lawrence, and Columbia rivers—was 46,000 billion gallons during May. These three large river systems, which include the flow of the Missouri and Ohio rivers, account for runoff from more than half of the conteminous United States and provide a quick, useful check on the status of the nation's surface-water resources.

Ground-water measurements were general ly average or above average throughout much of the country, reflecting the abovenormal precipitation patterns of the past sev-

Working in cooperation with federal, state, and local officials, USGS hydrologists routing ly collect information on the quantity and quality of the nation's surface- and ground water resources at more than 45,000 sites across the country. The highlights of May water-resources conditions are as follows:

The Big Five Rivers. Mississippi River at Vicksburg, Miss., 1,034 bgd, 88% above average and 35% above the April flow; Colum bia River at The Dalles, Ore., 269 bgd, 3% below average, but 84% above last month's flow; Ohio River at Louisville, Ky., 215 bgd. 153% above average and 46% above the April Bow: St. Lawrence River near Massena. N.Y., 182 hgd, 1% above average and 2% alloye last month's flow; and Missouri River at Flermann, Mo., 135 bgd, 127% above average, but 9% less than the April flow.

2. New York. In upper New York state. waters from Great Sacandaga Lake spilled over the Conklingville Dam for the hist time in its 53-year history. The overflow lasted 10 days, pushing the Hudson River to its highest flow levels since 1936.

North Carolina. Wet conditions continned throughout North Carolina during May, and several major streams were well above average for the fourth straight month. Flow of the French Broad River at Asheville, N.C., averaged 1.9 bgd, 39% above average for May, and flow of Contentnea Creek at Hookerton, N.C., averaged 479 million gallons a day, 53% above average. Ground-water levels in the state were generally 2-6 feet above the long-term averages for May and vere 1-6 feet higher than the levels this time

Iowa. Wet conditions persisted in much of Iowa. Flows of the Des Moines River at Fort Dodge, Cedar River at Cedar Rapids, and Nishnabotna River near Hamburg have

STREAMFLOW DURING MAY

been well above average now for 9 consecutive months. The Des Moines and Cedar rivers set new record high flows for the month. Flow of the Des Moines River at Fort Dodge averaged 5.1 bgd during the month, the sighest May flow in 51 years of record.

5. Minnesota. Streamflow conditions were varied throughout Minnesota. Streams in the northeastern part of the state were below average, while in the southwestern corner of the state, streams were above average. Flow of the Rainy River at Maniton Rapids, Minn., averaged 4.9 bgd during May, 58% below average. To the south, flow of the Minnesota River at Jordan, Minn., averaged 10.5 bgd, 195% above average, the second highest May flow in 49 years, and the eighth straight month that flow of this stream has been well

above average.
6. Utali-Nevada. In the western United States, heavy rains and sharply warmer temperatures inclied record-deep mountain snowpack in Utah and Nevada, resulting in torrential runoff, severe floods, and mudslides. Utali's land-locked Great Salt Lake rose more than 7 inches in May, to its highest level since 1924 and more than 3 feet higher than the level at this time last year.

7. Washington. Streamflow through most of Washington state was below average during May. Flow of the Skykomish River near Gold Bar, Wash., for example, averaged 3.2 hgd, 27% below average. This is the second straight month that the flow on this stream has been well below average.

8. California. Wet conditions prevailed across the entire state during May. All five of the key USGS index gauging stations in California reported flows that were well above average for the month. Flow of Arroyo Seco near Pasadena, Calif., averaged 41 million gallons a day, the highest May flow in 69 evels in the key wells in Los Angeles and Santa Barbara counties were all above average. The level in the key index well near Cuyama, in Santa Barbara County stood at 40 feet below the land surface, almost 74 feet above the long-term average, and highest in 33 years of record, (Map courtesy of the U.S. Geological Survey.)

Books

Recent Trends in Hydrogeology, 1982

T. N. Narasimhan (Ed.), Spec. Pap. 189, Geol. Soc. of America, Boulder, Colo., 448 pp.,

Reviewed by Mary P. Anderson

Recent Trends in Hydrogeology consists of a set of papers presented during a birthday party on February 9, 1979. The birthday par iv, or, more properly, the symposium, was convened to honor a distinguished hydrogeologist, Paul A. Witherspoon, on his 60th birthday. Many of the papers were written by Witherspoon's former students as well as by is current colleagues at the Lawrence Berke-

A preface by the editor (T. N. Narasimhan) wides an introduction to the volume and short commentaries on each of the 23 papers as well as ideas on probable future directions in hydrogeology. According to the preface, the purpose of the symposium was "to attempt a reasonable coverage of the important facets of hydrogeology" and "to provide a global picture of hydrogeology" where hydro-geology is defined as "the discipline concerned with those geologic processes that are nfluenced by water," presumably meaning subsurface water. Hence, the material covered in this volume is broad, ranging from topics traditionally associated with hydrogeol ogy, such as well hydraulics and regional flow system analysis, to more exotic subjects, such as geothermal resources and induced seismicy. As a result, only those with the most catholic interests will read all 23 papers.

However, all hydrogeologists are likely to relish the excellent critical review articles on contaminant migration in saturated unconsol idated material (R. W. Gillham and J. A. Cherry); statistical characterization of heterogeneous aquifers (S. P. Neuman); and flow test evaluation of fractured reservoirs, in vhich A. C. Gringarten presents a synthesis of methods, drawn from the geotechnical, geological, and petroleum literature, for evalunting the transmission properties of fissured formations. These three papers represent state-of-the-art summaries on three of the "hottest" new areas of hydrogeologic re-search. Most hydrogeologists will also be in-terested in R. A. Freeze's synthesis of groundwater-stream relationships using de-terministic and stochastic concepts, J. E. Gale's compilation of hydraulic conductivity measurements for fractured rock, and perspectives on regional flow system analysis by Bredehoeft, Back, and Hanshaw.

Of more specialized interest are T. N. Nar-

asimhan's insights into numerical modeling techniques as well as his ideas on the physics of unsaturated flow and D. C. Helm's paper on land subsidence. Others will be interested in papers on analytical solutions, well test instrumentation, the relationship between well loss and skin effect, groundwater problems in loss and skin effect, groundwater problems in mines, and physical properties of porous material. There is also an informative summary of past and current studies involving storage of energy in the form of relatively hot or cold water in aquifers (Tsang and Hopkins), as well as a lengthy paper by T. D. Show investigating the causes of induced seismicity upon reservoir filling, and four papers on various aspects of geothermal resources, in addition to the papers on fractured, rocks, there are to the papers on fractured rocks, there are two other papers addressing problems associ-ated with disposal of high-level radioactive

waste in a subsurface repository; an overview by S. N. Davis and a paper on isotopic dating of groundwater in crystalline rock by P. Fritz Last, there are a number of units conversion tables at the end of the book.

From a 1983 perspective, the current trends in hydrogeology that are accurately reflected in this collection of papers presented in 1979 are contaminant migration, flow through fractured rock and other aspects o mudear waste isolation, and stochastic processes, It could be argued that the other papers, which when taken individually are not really representative of strong trends in bydrogeology, when taken as a whole do reflect another current trend: the increasing interaction between hydrogeologists and those in related disciplines such as petroleum engineering, mining engineering, and soil mechanics. However, it is more significant that the volume does not contain any major papers addressing one of the strongest current trends in hydrogeology, deciphering and quantitying chemical reactions in the subsurface. There are sections on hydrogeochemistry in the lengthy review paper by Gillham and Cherry and in the paper by Bredehoeft et al. There also is a fairly specialized paper examining the chemical problems involved in the reinjection of geothermal brines, but there are no general review papers on chemical reactions in the subsurface. Perhaps the absence of papers on this subject suggests that questions related to hydrogeochemistry are some of the most difficult to address and even more difficult to answer.

The book measures 8½ x 11 inches in size, and the text is presented in two columns per page. The pages were produced from camera-ready copy generated by a word proces-sor; figures and tables are well done through-out. While the print is crisp and clear, the lines of type are single spaced, causing a lot of material to be packed onto each page. which may cause some eve strain with prolonged reading. The price may seem a bit steep, but at less than 8 cents a page, the book should be considered a bargain.

Mary P. Anderson is with the Department of Ge-ology, University of Wisconsin-Madison, WI

High-Precision Earth Rotation and Earth-Moon Dynamics: Lunar Distances and Related **Observations**

O. Calame (Ed.), D. Reidel, Hingham, Mass., xix + 354 pp., 1982, \$125.

Reviewed by John M. Wahr.

The last decade or so has seen the practical development of a number of high-precision, space-related geodetic techniques, specifically, lunar laser ranging (LLR), satellite ranging, and very long baseline interferometry (VLBI). One consequence has been an enlarged and improved data base available for

studies of lunar motion and earth rotation. The impact on lunar studies has been particularly striking. The vast improvement in lunar positioning data provided by the LLR/ experiment has revived interest in the previously lethargic business of modeling the lunar orbit and librations (librations are rotational displacements of the moon about its center of muss). Several numerical and analytical mod-

Yews

Leveling in Earthquake Area

The National Geodetic Survey (NGS) is performing first-order geodetic leveling in the Coalinga, Calif., area. The project, which is being funded by the U.S. Geological Survey (USGS), is intended to measure vertical height differences associated with recent Con-

linga carthquakes. The largest of the earthquakes occurred on May 2 with magnitude 6.5 (Richter scale). More than 1,500 attershocks have followed. including two on May 8, which were magnitude 5.5. Damage estimates exceeded \$30 million (see Eo. May 26, p. 387). No loss of life was reported, but 1,000 residents were

At the request of the USGS, NGS Mobile Field Party G-36 immediately began field reconnaissance and bench mark recovery operations. The first-order leveling, which totals approximately 50 km, will be completed by the end of June. Where possible, new leveling will follow lines of leveling previously per-formed in 1969 and 1972. This will provide an indication of vertical height differences during the intervening years caused both by subsidence in the area from man-made causes and by vertical height differences associated with the earthquakes. The data will be analyzed by NGS and USGS. Reports of the analyses should be written in July or August.

STARE System Looks at ULF Magnetics

STARE (Scandinavian Twin Auroral Radar Experiment) has analyzed magnetospheric ultralow frequency (ULF) waves in the ionosphere since 1977. STARE data analysis recently discussed by J. J. Singer of the Air Force Geophysics Laboratory, Massachusetts includes new explanations of the oscillations that occur in the shell structure of the geomagnetic field (Nature, May 5, 1983, p. 17).

The ULF pulsations (periods from tens of seconds to 10 min) were thought to be standing hydromagnetic waves that resonate on geomagnetic field lines. Singer describes of periods that increase as a function of latitude. This phenomenon may clarify the nature of their source and of the characteristics between individual oscillating geomagnetic shells. Singer notes the argument supporting the standing-wave theory as being the consistency of the wave periods with the time it takes Alfvén waves to travel along geomag-netic field lines between ionospheric reflection boundaries.

The STARE system, which is composed of two coherent pulse Doppler radars located near Malvik, Norway, and Hankasalmi, Finland, measures the ionospheric electric field by making the radar signals reflect from electrostatic waves excited in the E region of the auronal zone. The radar pulses scattered by the electrostatic waves are Doppler shifted in frequency as a result of the electron $E \times B$ drift velocity. Analysis of the scattered pulses yields values of amplitude and direction of the electric field in the region of overlap of the two radars. STARE has relatively high spatial (202 km) and temporal (20 s) resolution. The system is very beneficial for these measurements in that it takes data over a large area (400° km) simultaneously.

Recent STARE observations described by Singer include a number of transient events whose pulsation showed an increase in period with latitude. These events are apparently toroidal eigenmode oscillations, which are eastwest magnetic field perturbations. Because of Hall currents in the ionosphere, the oscillations were observed simultaneously as northsouth perturbations by a ground-based magnctometer. The observations are interpreted as being a simultaneous occurrence of oscillations from separate magnetic shells. Thus it was shown that magnetic field lines on adjacent shells can oscillate at different frequencies, implying only weak coupling between the lines. These measurements were possible because the STARE system is free of ionospheric screening effects. Comparison with ground measurements may yield information about the attenuation and screening phenom-

VLBI Observations

From the centers of quasars calculated to have velocities 10 times greater than that of light—the Einsteinian constant of the universe—astronomers are finding explanations of Doppler effect red shifts of emission. Very long baseline interferometry (VLBI) arrays have been used to examine the cores of seven known radio sources in space that are characterized by superluminal velocities, and a significant amount of knowledge has been gained about red-shift phenomena of plasma sources. Milliarcsecond resolution of VLBI techniques allows observers to examine in de-

tail central structures of radio sources. According to a discussion of observers at the recent superluminal workshop held at the Jodrell Bank Observatory, U.K., February 1983, "The last six years have brought a great increase in reliability of results, particularly because of the use of VLBI arrays. . ." (Nature, April 28, 1983). This reliability has resulted in a compilation of properties of radio-source core structures. The steep frequency-shifted radio spectrum of a superluminal structure is apparendy caused by rapidly extending plasma jets. The discussion provides the following explanation of a relativistic jet: "...a relativistically moving stream of plasma emanating from the core. .. [whichl. . is identified with the base of the jet. . . The 'moving' components are shocks or plasmous moving down the jet, which point toward the observers in the case of superlu-minal sources" (Nature, April 28, 1983). The idea is that illusions of Doppler effect red shifts can be produced by high-energy physi-cal phenomena other than simple velocity effects. Even in the case of a source moving away from an observer with a relative velocity less than the speed of light, an illusion of su-perluminal velocity results because the angle of view is small ("because the observer's view of the early part of the motion is delayed with respect to the later parts, and hence the apparent duration of the motion is short-

ened" (Nature, April 28, 1983)). Another effect that can cause illusory red shifts is the so-called "Doppler favoritism" phenomenon, which is a similar "small angle" effect that results in an enhancement of flux density. Curiously, superhuninal sources have are second jets located only on one side of the nucleus, as well as the central milliarcsecond jets. These jets could be "Doppler favorites" or they could simply be unexplained properties of radio sources. The research on these unusual radio

sources also examines the small angle phe-

nomena. There are theories that relate the

observed strengths of quasars to their line-ofsight angles; sources with weak radio cores and double outer lobes are at large angles and vice versa. A number of problems in explaining "classical double" radio quasars have arisen from recent measurements.

There are many ideas emerging on how to explain the observations. Some observations can be explained if the jets are released from the cores as a sort of plasma spray, the angle of view being a function of visual collimation of a portion of the jet. Other observations seem to require the existence of single, nar-

Certain broad theory explanations include the origin of galactic phenomena. According to one such theory discussed at the workshop: ". . the Galactic Center, Seyfert galaxies, and quasars are interpreted as reflecting just two intrinsic parameters—the mass of the central compact object (black hole) and the accretion rate into it" (Nature, April 28,

Year of Oceans?

John V. Byrne, administrator of the National Oceanic and Atmospheric Administration (NOAA), has proposed that 1984 be observed as the Year of the Oceans. The year should be devoted to defining and clarifying the U.S.'s ocean and coastal goals and "rally-ing the support to achieve them," Byrne recently told oceanographers attending the Coastal Zone '83 gathering in San Diego, Cal-

"Today we see ferment in ocean and coastal concerns," Byrne said. Among the examples he cited was the proclamation issued by President Reagan on March 10 declaring an exclusive economic zone within 200 miles of the coast where the United States will exercise jurisdiction for the purposes of exploring, exploiting, conserving, and managing natural resources (Eos, June 7, 1983, p. 402). In addition, "legislation has been introduced to define the outer continental shelf, deep seabed minerals, ocean thermal energy, marine pollution, fisheries, and other oceanic concerns," Byrne said. "In both houses of the U.S. Congress, legislators are considering bills that would establish a National Oceans Policy Commission," he added.

NOAA's administrator also urged tha and private organizations share in the effort to provide strong marine programs. "Only with active participation and guidance by the private and state sectors can the federal government discharge its responsibilities effi-

Earth Dating by Ion Probe -

The ion microprobe is an instrument that is finally coming into its own in isotope and trace-element analysis of particulate mineral samples. The idealized ion microprobe would be able to analyze sample volumes of less than one cubic micrometer. The analysis would include major-element bulk composi-tion and the chemical formula of the mineral being analyzed. More essential, the analysis would also contain trace-element composition and isotopic abundances because the ion miand isotopic abundances occause the ion interprobe employs a mass specifograph as its analytical device. Ideally then, an investigator would be able to obtain major, minor, and trace-element data and be able to date geo-There are the small-angle phe logically a small portion of a mineral crystal instantaneously and simultaneously. That this

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els of the orbit and librations have been developed over the past few years. Numerical models, constructed by numerically solving appropriate differential equations, are gener more accurate than existing analytical models and are, in principal, better suited to removing the effects of hunar motion from the LLR residuals. On the other hand, results from numerical models are less amenable to physical interpretation, and so analytical

models continue to receive attention. Analytical models are particularly useful in trying to understand the lunar librations, both because of the possibility of excited free librations and because the dynamical behavior of the moon during the forced librations is not completely understood.

So far, the new georletic techniques have had less of an effect on earth rotation studies. Rotation data from traditional optical astrometry are still competitive at periods of a few months and longer. The most pronounced advantage of the new techniques is their abili-ty accurately to determine changes in rotation (i.e., pole position and rotation rate) at periods between a few days and a few months. But it appears that most of the geophysically useful signal occurs at longer periods.

Both lunar motion and earth rotation results derived from the new techniques were discussed at the International Astronomical Union (IAU) Colloquium 63, held in Grasse, France, during May 22–27, 1981. This book constitutes the proceedings of that colloquium. It will probably be of little interest to people who have no working knowledge of the field, primarily because, in common with other conference proceedings, the 37 contributtons here are short and not designed for a general audience. (There are some arguable exceptions, most notably a summary by J. Henrard of existing analytical models of the lunar orbit; a presentation by D. S. Robertson and W. E. Carter describing results from VLB1; and contributions from J. Dickey, H. Fliegel, J. Williams, and C. Yoder describing the Jet Propulsion Laboratory (JPL) reduction of LLR data.)

But an additional factor here is that the subject has not yet developed to the point where results can be routinely interpreted in terms of geophysical or lunar processes. The reader expecting to learn anything generally useful about the earth or moon will be disappointed. On the other hand, the book does give a representative picture of the current state of the subject. And although the held is rapidly evolving, the problems and techniques described here will probably be around for some time.

It is not possible to provide more than a brief description of the contents of these proceedings. (A more complete discussion can be found in Byron Tapley's report on the collo-quium published in Eus., January 26, 1982, p. 132.) Most of the earth rotation work presented here is concerned with the data analysis. There are contributions from groups at JPL, the Massichusetts Institute of Technology, and the Centre d'Études et de Recherches Géodynamiques et Astronomiques describing their current efforts at reducing the LLR data. There are discussions of the analysis of VLB1 data and of data obtained from rang-ing to the GPS and Navy Navigation satellites. (Two presentations describing results from ranging to the LAGEOS satellite are presented here by abstract only.)

There are also several attempts to combine and compare rotation data derived from competing techniques. Other earth rotation contributions include a description of Chinese efforts in the field, discussions of the 1980 IAU nutation series, and a description by J. Williams and W. Melbourne of a possible future problem associated with adopting fixed precession and equinox corrections. The one case here where the results permit geophysical interpretation, a study by Lang-

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lev et al. relating variations in the earth's rotation rate to changes in atmospheric angular momentum, is represented in these proceedings by abstract only.

Most of the lunar motion studies are concerned with modeling the hunar orbit. Most important is probably a description by J. Chapront and M. Chapront-Touzé of their improved analytical model that includes the etfects of planetary perturbations. Other orbital studies include quantitative comparisons of numerical and analytical models and discussions of the orbital effects of earth tides and general relativity. The one attempt to use the observed orbital results to learn new physics is a study by T. C. Van Flandern of a possibly changing gravitational constant, but it is represented here only by its abstract.

Lunar libration results are more immediately accessible to useful physical interpretation than are the lunar orbital studies but are not nearly as well documented in these proceedings. D. H. Eckhardt describes an improved analytical libration model that includes the planetary and earth figure perturbations. The other libration-related contribution, a general review by R. W. King, is represented here by abstract and bibliography only. Other lunar and orbit-related studles are discussions of selenodetic reference frames and a development by R. Broucke and W. Presler of a small parameter expansion of the disturbing function for the three

John M. Wahr is with the Department of Physics and the Cooperative Institute for Research in Envitonmental Sciences, University of Colorado, Boul-

Isotope Studies of **Hydrologic Processes**

E. C. Perry, Jr., and C. W. Montgomery (Eds.), Northern Illinois University Press, 118 pp., 1982, \$25.

Reviewed by D. I. Siegel

During the past decade, the study of environmental isotopes has become an increasingly powerful tool toward understanding hyrologic processes. The present book, a selection of twelve papers presented at the 1980 Midwest American Geophysical Meeting, is a useful addition to the literature of isotopic methods used in hydrologic studies and will be of particular value to those interested in groundwater flow system analysis and groundwater chemistry.

The papers deal with the stable isotopes of oxygen and hydrogen in water; carbon in bicarbonate; sulfur in sulfate and sulfide; and the radioisotopes of uranium, hydrogen, and radium. The first paper, by the editors, provides a brief but succinct introduction on isotopic processes. Of particular interest to this reviewer are papers by Perry et al. and Desaulniers et al., who explain isotopically light groundwater (bisO about 5% lighter than modern recharge water) in Illinois bedrock aquifers and clayey Pleistocene deposits in south-central Canada as Pleistocene recharge during colder climates. Desaulniers et al. used ¹⁴C to demonstrate that the isotopically lighter waters in the Pleistocene deposits

could be up to 13,000 years B.P. Not all hydrogeologic systems are so relatively well defined isotopically. Fritz and Frape show that Ca-Na-Cl brines, found in bedrock on the Canadian Shield, are isotopically heavy, and plot above the "meteoric waterline" on a δ_{18} O versus δ /mdD diagram. The genesis of these waters is unknown, but bly related to rock/water interaction. Rock/water interaction in the active Ngawha geothermal system in New Zealand is discussed in detail by Blattner who shows that

didate. Application deadline is July 15, 1983, although search will continue until position is filled

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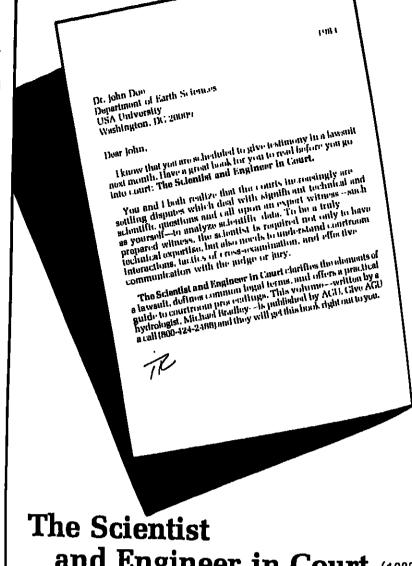
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a positive shift in $\delta_{\rm B}O$ in the geothermal waters can be nonuniquely explained by interacting tion of reservoir rock with both meteoric and magmatic waters. Similarly, a paper by Krothe on sulfur isotopes in groundwater systems on the Ogallala Formation, southwestern Kansas, and the St. Louis limestone in southern Indiana illustrates the difficulty in differentiating among isotopic sources, sinks,

and modifying geochemical processes. The only paper on isotopes in surface water, by Sklash and Farvolden, is mainly a summary of their previous work, and restates the hypothesis that a major portion of stormflow in small watersheds may be groundwater. The proposed cause of accelerated groundwater discharge during storms is the growth of transient groundwater "ridges" or mounds near the stream. Although this hypothesis may be considered provocative to some hydrologists, studies of hydraulic gradients near lake shores also have shown the existence of transient groundwater mounds after large storms.

Papers on radioisotopes are equally varied

Research Scientist/Space Plasma Physics, University of Iowa. A research position is available in the Department of Physics and Astronomy. The University of Iowa, for theoretical and interpretative studies of waves in space plasmas. Specific emphasis is on theoretical investigations of wave-particle interactions in planetary magnetospheres and in the solar wind. These investigations are to support the interpretation of data being obtained from spacecraft projects such as Dynamics Explorer. International Sun Earth Explorer and Voyager. The applicant must have a Ph.D. with good qualifications in plasma physics theory and shoud have some experience in the interpretation of space plasma physics data. Send a resume and the names of three references familiar with the applicant's work to: D.A. Gurnett, Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242, telephtuse 319-353-3527.

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th content. A paper by Michel et al. pres gamma ray spectroscopy as a method tode termine activities of 228Ru and 226Ra. Uran um and radon concentrations in aquifers east-central Minnesota are described by Lo ly and Morey, and Gilkeson and Cowarder lated uranium disequilibrium to redox part tial along a groundwater flow path in nonlicastern Illinois. Tritium was used with subisotope data by Stewart and Downes to idea ly different water masses in a spring in No.

Isotopic Studies of Hydrologic Processes is 3 book that presents some interesting work through case studies as well as information a more general nature for the scientist into ested in learning how to use isotopes as 3 k in hydrologic research. The cost of the box however, may limit widespread distribution A soft cover edition would perhaps have been

D. I. Siegel is with the Dopartment of Geolog-Syracuse University, Syracuse, NY 13210.

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pplicants with experience, publications, and/or morable existing research equipment preferred. Preferred starting date would be January 1, 1983. Closing date for applications is October 1, 1983. Applications should include statement of research and leaching interests, experience, a full vitae, and four letters of reference.

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mative action. Section 504 employer Research Scientist for International Ground Water Modeling Center. A position is immediately available for a Research Scientist in the International Ground Water Modeling Center. IGWMC is an international information center for ground water modeling. It organizes an annual operates a clearinghouse for ground water models, conducts a program in applied research on ground water modeling, and publishes the Ground Water Modeling Newletter.

The successful aplicant will have a Ph.D. in Civil

The successful aplicant will have a Ph.D. in Civil Engineering/Hydrology with a background in quantitative ground water hydrology, including chemistry of ground water. The person must have a least one (I) year experience in modeling flow and transport processes and should be acquainted with related recent research. A solid background in numerical and stochastic analysis is required. Incumbent will perform the applied research program of the Center, including exploring modeling needs and research trends, and technical evaluation of models, and will be involved in the continuous updaing of programs, and in handling information updating of programs, and in handling information

requests.

The annualized salary for the position is \$28,000 for a \$7.5 work week, typoically from \$130 a.m. to

for a 37.5 work week, typescary, 1500 p.m.
Interested applicants must include 1D number 042860 and social security number in a response by July 28, 1983 to:
Indiana State Employment Service
10 North Senate Avenue
Indianapolis, Indiana 46201
Auention; W.F. Shepherd

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Argonne National Laboratory/Chemistry Division. An immediate postductoral position is available for amospheric chemistry studies based on mass for amospheric chemistry studies based on mass spearometric analysis of the stable isotopic composition of atmospheric trace gases. Problems inclinde source budgets and temporal variations of atmospheric trace gases and determination of atmospheric trace gases and determination of atmospheric of trace gases and determination of atmospheric performance of the preparation of gas samples derived from trace gases using carrier gas train systems with cryogenic and demical separation methods and precision mass spectrometric analysis. Send resume of Mr. Walter Weller Weller Personnel Division, Box D-CHM-80, Argone National Laboratory, 9700 South Casa Avenue, Argonne, Illinois 60439.

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ontdoctoral Position/Naval Postgraduate School. The Ocean Turbulence Laboratory has available a ne Ocean Turbulence Laboratory has available a postdoctoral position for a person interested in the analysis and interpretation of oceanic turbulence data. The tenure is for one to two years. The successful candidate should have a 19t. D. in physical oceanography and although experience with turbulence data is preferable it is not essential. The opportunity for involvement in data gathering expeditions is also available.

Resumes can be seen to Dr. R.G. Lunch, Code. Resumes can be sent to Dr. R.G. Lueck, Corle 68Ly, Naval Postgraduate School, Monterey, CA

An Equal Opportunity/Affirmative Action Em-

Research Professor in Marine Geoscience/University of Rhode Island. The Graduate School of Oceanography invites applications for a research professorship in Marine Geoscience whose salary and rank are negotiable. Preference with he given to cantidates who have clearly demonstrated abilities and interest in but not necessarily limited to paleomagnetism. The position is funded by contracts and grants, however the research professor holds full laculty rights in addition to other benefits. The paleomagnetic facility at GSO is fully equipped, fully operational and oriented towards rapid measurement of large numbers of soft sedimentary samples. Applications are now open for the position which will become available about January 1, 1984.

Send letters of application, resume, and names and addresses of three professional references to: Roger L. Larson, Graduate School of Oceanography, University of Rhode Island, Narragansett. Rhode Island 02882.

An aftermative action/equal opportunity employer nu/f.

scientist I/National Center for Atmospheric Research. To work under the supervision of the reactive gases project leader. Will plan and oversee major elements of field experiment; develop analytical techniques appropriate to field and laboratory use; and analyte, interpret and model the data gathered. Requirements include; PLD. in atmospheric science or equivalent knowledge and skill, with a strong basic knowledge of atmospheric chemical and chemical knetics; skills in research demonstrated by publications; skills and experience in analytical chemistry of acrosol and gaseous and aqueous atmospheric substances; skill in design, testing and implementation of chemical analytical techniques; skill in development of computional models parameterization of atmospheric, physical and chemical processes, and application of numerical and stanistical techniques. Scientist I appointments are four term of up to three years. Individual may be appointed to the next higher level of scientist in accordance with the UGAR Scientific Appointment Policy. Salary: \$25.814 to \$37.722 annually. To apply contact: Esther Balzon. (303) 494-5151 extension 581 or send resume and list of publications to NCAR Employment, P.O. Box 3000, Boulder, CO 80307.

An equal opportunity/affirmative action employ-

Physical Oceanography/University of Rhode Island. A postdoctoral research associate position is available starting October 1, 1983 for studies of tropical processes in the Pacific. The research involves the collection and analysis of data relating to the dynamic topography and zonal pressure gradients of the equatotial current systems as part of a long-term study of ocean influences on chinate. Submit resume and professional references by August 15, 1983 to: Dr. D. Randolph Watts, Marine Research Associate II Position, UNIVERSITY OF RHODE ISLAND, 199, Box 357, Kingston, Rhode Island 02881

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lowa State University of Science and Technology, Department of Earth Sciences/Research Associate; Electron Microprobe. The Department of Faith Sciences invites applications for a Research Associates

twelve-month position. Salary will be commensurate with qualifications.

It imary duries are the operation and maintenance of a fully automated microprobe with WDS and EDS capabilities and the supervision of associated laboratory facilities. Additional duries include the istruction of research personnel in instrument operation. Ample opportunities exist for conducting collationative and independent research involving the inicionallysis of geological materials. Applicants should have a M.S. degree in a science

Applicants should have a M.S. degree in a science or engineering field, or equivalent experience, and experience with electron beam instrumentation. Persons with a working knowledge of WDS and EDS spectrometers and the accompanying computer operations and experience analyzing geological samples will be preferred applicants.

Application deadline is July 31, 1983. Later applications will be accepted if the position is not filled. Applications should include a complete resume, a statement of background and interests, copies of publications and names of at least three references. Applications and names of at least three references.

ations should be sent to :

Bert E. Nordlie

Department of Earth Sciences

lowa State University 253 Science 1 Ames, Jown 50011 Iowa State University is an equal opportunity/af-firmative action employer.

Faculty Position in Marine Geology/University of Maryland, Center for Environmental and Estuarine Studies (UMCRES). Horn Point Fuveronmental Laboratories of UMCRES invites applications for a Laboratories of UMCRES invites applications for a laboratories of UMCRES invites applications for a laboratories of UMCRES invites applications. Laboratories of UMCEES invites applications for a tenure track research faculty position trank open) for a marine geologist. The successful andidate will join a growing physical/geological occanography program, so applicants with a wide range of interests will be considered. Opportunities exist for interdisciplinary research with hidogical and chemical occanography programs. Although some preference will be given to candidates with interests in estuarine and continental shell sedimentological processes, the primary criterion for selection is the ability to develop a strong research program. The closing develop a strong research program. The closing date for applications is August 1, 1983. Curriculum vitae, description of research interests and list of references should be sent to:

Dr. Larry G. Ward Chairman, Search Committee UMCEES

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Horn Point Environmental Laboratories
P.O. Box 775
Cambridge, Maryland 21613.
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Professor of Meteorolgy/University of Maryland.
The Department of Meteorology at the University of Maryland, College Park, invites applications for a tenure line Professorship. We seek a well-established, highly recommended scientist with an outstanding international reputation in atmospheric and oceanic modeling and applications. We propose the establishment of a center to study the interactions of atmosphere, ocean and land processes and their impact on climate variability, and in particular to study the feasibility of short term climate predictions. The applicant should be qualified to head such a Center, plan its projects, organize its activities, and bring to the University the necessary resources to attract outstanding scientists on the Center and to carry out its research functions. Salary is negatiable. To apply, please send a complotee viace and the names of references to the Chairman, Search Committee, Department of Meteorology, University of Maryland, College Patk, MD 20742. Applications received by 22 july 1983 will receive full consideration.

Applications received by 22 juty 1985 win receive full consideration.

the University of Maryland subscribes to policy of equal educational and employment opportunity.

The University of Maryland is requed by Title 18 of the Education Amendment of 1972 not to discriminate on the basis of sex in admission, treatment of students or employment. ment of students or employ

Chairman—Department of Geological Sciences, Wright State University. The Department of Geo-logical Sciences, nivites applications for the postern of chairman, to be appointed September 1984. We seek a dynamic individual with administrative talent and an appreciation for research and practice-related educational activities. Rank is at the full profesen cuttational arrivates. Rails by the full profession level and two restrictions have been placed on ateas of specialization. The department is active with 12 faculty and an emphasis on professional practice, yet maintaining a firm commitment to basic re-

Send a letter of application, corriculum virae and

Chairman, Search Commutee Department of Geological Sciences Wright State University Origin State Cinversity
Davion, Old 45435.
Wright State University is an affirmative action/
equal opportunity employer. Closing date for the
position is October 31, 1983.

University of Arizona/Faculty Position. The De-partment of Underlogy and Water Resources invites applications for a faculty position in hydrology with a specially in ground-water chemistry. Cambidates in the training and/or professional experience in hydrogeology and must have demonstrated abili-ties in the quantitative aspects of the topic. Appoint-ment will be at the level of an assistant or associate professor. Interested individuals should obtain fur-ther information from:

ther information trom: Professor Stanley N. Davis Chairman, Search Committee Department of Hydrology and Water Resources University of Arizona Tucson, Arizona 85721 602-621-3131. The University of Arizona is an affirmative ac-

Marine Research Associate II. Analyze and inter-pret time series of vertical acoustic travel time and bottom pressure. Prepare progress reports and sci-endific manuscripts on these results. Assist in plan-ning experiments and participate in scientific cruises. Ph.D. in physical oceanography plus experi-ence in computer programming with times series

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applications in FORTRAN. Submit application and resume by August 15, 1083, to: Dr. D.R. Watts, Marine Research Associate 11 Position, University of Rhode Island, P.O. Box 357, Kingston, Rhode Island, 1988.

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STUDENT OPPORTUNITIES.

Graduate Assistantships/Howard University.
Howard University in Washington, D.C., offers a new graduate program for the M.S. degree in geoscience; made possible by a grant from the Gulf Oil Company. Areas of specialization are field geology geophysics, geochemistry, and meteorology/hydrology with remote sensing. Some stiperals and assistantships are available. Potential students should write to Dr. Eric Christofferson, Department of Geology and Geography, Howard University. Washington, D.C. 20059.

SERVICES, SUPPLIES, COURSES, AND

Ground Based Airglow and Aurora Optical Science Facilities Workshop. U.S. airglow and auroral scientists interested in ground based optical observations have formed a facilities definition group. servations have formed a facilities definition group. Their main purpose is to assess the need and to plan for the development of modern state-of-the-articalities to but her the investigation of the major scientific problems within the field. The group sciented Dr. I vie Broadhor (USC) Income as charman, Dr. G. Romick (Uol. A. Farbanko as secretary, Dr. W. Hansen (Univ. of Texas-Dallas). R. Eather (Boston College, Chestina Hill), G. Hernandez (NOAA-Bonkler), M. Torr (Utah State-Logan), P. Hays (Uol Michigan-Ann Arbor) and R. Roble (NCAR-Bonkler) members of the organizing committee.

mittee.

An initial workshop has been scheduled for August 1, 2, and 3, 1985 in Lyagan, Utah, The Format gost (, 2, ant 3, 1985 in Fogan, Claif, The formal will consist of invited speakers to review, chemistry and dynamics of the stratosphere, mesosphere and thermosphere; chemistry, modeling, spectroscopy and applications to the magnetosphere in autorial physics; and current ground based facilities (sites and instrumentation) used in interferometry, spec-troscopy, photometry and imago in airglow autoral

The intent of this workshop is to initiate the development of a working paper describing the scientific goals, the implementation policies, and the description and location of the major facilities needed within this field. Also to be included will be a discussion of the need for enhanced communication within this group of scientists; the possibility of more formal organization; and the rationale for an annual topical meeting.

A complete agenda will be distributed to all scientists on the current mailing list. Anyone wiching to obtain further information can contact any member of the organizing committee. All scientists interested in this area of aeronomy are invited to attend. Specific details on the workshop will be available and distributed by the first week in July.

<u>Meetings</u>

Announcements

Penrose Conference

The Geological Society of America Penrose Conference entitled "Melanges of the Appalathian Orogen" will be held June 23-30, 1984, in Newfoundland, Canada. The conference will focus on the origin, significance, and characteristics of melange in distinct geological settings. The importance of careful field observations in deciphering melange ierranes will be emphasized. As such, much of the conference will center around in situ field discussions; Newfoundland offers a d cross section of the Appalachian oroger and its melanges.

Send resume and names of three references in L. Grossman, Department of the Geophysical Science. University of Chicago, 5734 S. Ellis Avenus, Chicago, 1L 60837. The conference will begin on Newfoundland's west coast with excursions to melanges The University of Chicago is an equal opportunity associated with the assembly and emplacement of Ordovician allochthons onto the an-Hydrogeologist. Converse Consultants is setting a staff or project level hydrogeologist for project level hydrogeologist for project waste disposal, mineral and energy developings and geotechnical projects. Las Vegas-based, who serve primarily in the southwestern U.S. Opportunity for interaction with an expanding staff of power stones in six regional offices. Excellent salary and advancement potential.

Minimum requironments are an advanced degree in geology plus two to five years experience in geology plus two to five years experience in geology in the staff of groundwater flow, contractor supervision do groundwater flow, contractor supervision communication skills are essential. Additional transcential contractor of the supervision of the supervision. Confidence in geophysics and hydrology is ing or experience in geophysics and hydrology in desirable. Contact Dr. Robert F. Kaufman, the supervision. Spencer Street, Suite 120, Las Vegas, NV solles. cient continental margin of North America. Next on the agenda is the Burlington Peninsula, where scientists will be able to examine polydeformed and metamorphosed melanges associated with the deformed easterly edge of the ancient continent; the melange of imbrifaied ophiolite that comprises the suture zone etween continental and oceanic terranes; and associated olistostromes deposited immediately after the destruction of the margin. The final field area will be the controversial Cambro-Ordovician Dunnage Melange, located in the easternmost part of the ancient oceanic terrane, and the Silurian olistostronies of lew World Island.

Interspersed with these field trips will be formal and informal discussions on the origin, significance, and correlation of melanges along the Appalachian orugen; comparisons of Appalachian melanges with those of other orogens; and general melange topics such as modes of origin and structural and strati-

graphic characteristics. For more information, contact, before February 1, 1984, Brenna E. Lorenz, Department of Earth Sciences, Memorial University Newfoundland, St. Johns, Newfoundlan A1B 3X5 Canada, Lorenz, Nick Rast (in the geology department at the University of Kentucky, Lexington), and Harold Williams (in the earth sciences department at the Memorial University of Newfoundland, St. John's, Newfoundland) are the convenors.

Ophiolites :

The working group on Mediterranean Ophiolites will hold its second annual meeting at the Istituto di Mineralogia, Petrografia e Geochimica, in Florence, Italy, on December 15-17, 1983.

Focusing on oceanic tectonics and metamorphism, the meeting will consider the structural and metamorphic history of ophiolites during the period between their forma-tion and their involvement with the continental crust. Similar events in present-day oceanle settings may also be discussed.

Abstracts, not to exceed one typed page, should be submitted by September 30, 1983, to Giovanni B. Piccardo, Istituto di Mineralo.

gia, Petrographia e Geochimica-Università. via La Pira 4, 50121 Firenze, Italy. All abstracts and papers, whether or not accepted for presentation at the scientific session, will be published in a special issue of Ofioliti.

Hydrologic Forecasting

The American Water Resources Association (AWRA) symposium entitled "A Critical Assessment of Forecasting in Western Water Resource Management" will be held in Seattle, Wash., on June 11-13, 1984. The symposium will focus on the science of hydrologic and demand forecasting and its relationship and significance to operational, planning, and policy decisions by both the public and the private sector in the western United States.

A session on the operation of water resource systems will focus on the use of very short-term hydrologic and demand forecast-ing for the improved operation of existing systems. Among the topics to be included are short-term river flow/river forecasting techniques, long-term (monthly to seasonal) runoff forecasting techniques, and methods to incorporate forecasts and forecast uncertainty. in system operation policies. ...

Another session, on capital program planning and implementation, will focus on the planning of capital facility expansion for water resource systems. Among the topics to be covered are long-range and very long-range water demand forecasting techniques; evaluating trends and uncertainty of social, economic, and technological factors, and their relationship to water demand forecasting: and methods for evaluating the economic loss from failing to meet demand growth.

Abstracts, not to exceed 200 words, should be sent no later than November 1, 1983, to the general chairperson, Gary R. Minton, Lynn Street, Seattle, WA 98109.

AWRA Conference

The American Water Resources Association (AWRA) will conduct its Ninetcenth Anitual Conference and Symposium on October 9-IS, 1983, in San Antonio, Tex.

 The conference on unalysis and management of land drainage and flood waters will feature 20 technical sessions on such topics as planning for stormwater ranoff; nonpoint source water pollution problems; stormwater quality, flood plain management, and flood control planning; water resources computations by microcomputer; and remote sensing as a planning tool. Fifteen technical sessions on regional and state water resources planning will deal with such topics as changing roles in water resource financing, federal versus state versus regional responsibilities, water importation or interbasin transfer issues, and state and regional groundwater management issues.

For preliminary program and registration information, contact Kenneth D. Reid, Executive Director, AWRA, Suite 220, 5410 Grosvenor Lane, Bethesda, MD 20814.

Postdoctoral Position in Igneous Petrology/North-ern Illinois University. Position is far one or two years. Position involves collection and analysis of geochemical data on basic plutonic rocks, but time will be available for writing and research on inde-pendent projects. Experience with probe, XRF, INAA, and geochemical modeling of igneous rocks is preferred, candidates willing to teach an introduc-tory petrology course during spring semester will be given preference. Surfing date will be August or September, 1985, depending on availability of can-

430

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September 14

Call for Papers

Abstracts must be received at the AGU office by 5:00 P.M. on September 14. Late abstracts (1) may be summarily rejected by program chairman, (2) may not be published in advance of the meeting, or (3) if accepted, will be charged a \$25 late fee in addition to the regular publication charge.

The 1983 Fall Meeting of the American Geophysical Union will be held in San Fran cisco from December 5–10 at the Cathedral Hill and Holiday Inn/Colden Gateway hotels. Blocks of rooms are being held at the Cathedraf Hill, the Holiday Inn/Golden Gateway, the San Franciscan, the Holiday Inn/Cavic Center, and the Grosvenor Inn. Correspond ing authors will be sent housing and registration forms. In addition, the forms will be

General Regulations

Abstracts may be rejected without consideration of their content if they are not received by the deadline or are not in the proper format. Abstracts may also be rejected if they contain material outside the scope of AGU activities or if they contain material already published or presented elsewhere. Only one contributed paper by the same first author will be considered for presentation; additional papers (unless invited) will be automati cally rejected.

Only AGU members may submit an abstract. The abstract of a nonmember must be accompanied by a membership application form (with payment) or it must be sponsored by an AGU member.

There is a publication charge of \$40 (\$30 if prepaid) for each abstract. If the first author is a student, the publication charge is \$20. Both invited and contributed papers are subject to the publication charge. Prepayment of the publication charge can save money. Send a check for \$30 (\$15 for students) with your abstract. The abstract must be received at AGU by September 14 to avoid an additional

\$25 charge. AGU will acknowledge receipt of all abstracts. Notification of acceptance and scheduling information will be mailed to corresponding authors in late October.

Abstracts

The abstract page is divided into two parts: the abstract itself and the submittal information. Follow the instructions for both carefully. Please use a carbon ribbon to type the material, and do not exceed the maximum di-Abstracts that exceed the noted size limitations will be trimmed to conform.

The meeting program will be prepared by photographing the abstracts exactly as they are received. Use the model abstract to prepare the final version. Submission of an abstract for an AGU meeting is presumed to carry with it permission for AGU to reproduce the abstract in all editions of Eos and in the programs and reports relating to the meeting. It is also presumed to permit the free copying of those papers. Although Eor is a copyrighted journal, authors are not requested to transfer copyright. Copyright, where it exists, will be reserved by the au-

Submittal Information

Numbers refer to the items in the submittal block on the sample abstract.

1. Title of meeting.
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name must also appear on the abstract at the end of the author portion). If no 1D number is given, a membership application and dues ayment must accompany the abstract. Call AGU (800-424-2488 or 462-6903 if you are in the Washington, D.C., area) immediately if

you need an application. 3. Corresponding address: Give complete address and phone number of author to whom all correspondence (acknowledgment and acceptance letters) should be sent. Abbreviate as much as possible.

4. Section of ACU to which abstract is ubmitted (use the following letter abbreviations): A (Atmospheric Sciences); G (Geodesy); GP (Geomagnetism and Paleomagnetism); H (Hydrology); O (Ocean Sciences); P (Planetology); S (Seismology); SA (Aeronomy); SM (Magnetospheric Physics); SC (Cosmic Rays); SS (Solar and Interplanetary Physics) ics); T (Tectonophysics); V (Volcanology,

Geochemistry, and Petrology); U (Union). 5. Type title of special session (if any) to which submittal is made.

6. Indicate your preference for a particular kind of presentation by one of the following letters: O, oral; P, poster. The chairman may assign you to either of these types of presentation in order to fit his program plan.
7. Percent of material previously present-

ed or published, and where. 8. Billing information:

(a) Complete billing address if other than the corresponding address (item 3 above). (b) If purchase order is to be issued, indicate number upon submittal of abstract. Invoices returned to AGU because of insufficient billing information will be assessed an additional charge of \$10.00.

(c) If a student member is the first author, the student publication rate is applicable. Indicate that the student rate is applica-

If prepaid, enter amount enclosed. Indicate whether paper is C (contributed) or I (invited). If invited, list name of in-

Poster Sessions

A large, centrally located meeting room will be set up for poster presentations. Experience from recent AGU meetings and from other scientific societies has shown that a poster presentation, while more demanding of the author, can provide a superb opportunity for comprehensive discussions of research results. Some sections are organizing poster sessions on specific topics, and contrib uted papers on these subjects will automatically be scheduled as posters. In other sections it may be necessary to assign papers to poster sessions even though the authors requested oral presentation.

Presenters of poster papers are reminded that a poster exhibit requires careful preparation. Figures and text will be scrutinized in detail, and authors must be prepared to discuss the contents of their papers in depth. Under these conditions, well-prepared figures and concise logical text are essential.

Program Committee

Meeting Chairman H. Frank Eden, NSF Almospheric Sciences (A) Ronald Taylor, NSF Geodesy (G) William Sjogren, Jet Propulsion

nagnetism and Paleomagnetism (GP) Subir K. Banerjee, University of Minnesota Hydrology (H) Dennis P. Lettenmaier, University of Washington, Seattle

Ocean Sciences (O) Dave Cutchin, Scripps Institution of Oceanography
Planetology (P) Richard J. Terrile, Jet Propulsion Laboratory

Seismology (S) Robert J. Geller, Stanford

SPR Aeronomy (SA) Raymond G. Roble, NCAR SPR Cosmic Rays and Solar and Interplanetary

Physics (SS/SC) Miriam A. Forman, SUNY, Stony Brook SPR Cosmic Rays and Solar and Interplanetary Physics (SS/SC) Bruce T. Tsurutani, Jet uision Laboratori

SPR Magnetospheric Physics (SM) Michael Schulz, Aerospace Corp.
Tectonophysics (T) Raymond F. Jeanloz, Uni-

versity of California, Berkeley Volcanology, Geochemistry, and Petrology (V) Peter W. Lipman, USGS

Special Sessions

Polar Research

Geomagnetism and Palcomagnetism (GP)
Applications of Palcomagnetism to Tectonics
of the Western United States

Electrical Conductivity of the Crust and Up-per Mantle—Field Methods and Laboratory lessurements (in cooperation with the Committee on Mineral Physics)

Problem Solving With Rock Magnetic Techniques-Case Histories

Hydrology (H)
Glacier-Ocean Interactions (jointly sponsored with Ocean Sciences)

with Ocean Sciences)
Instream Flow Requirements for Fish: Methodologies, Implementation, and Impacts
Muldvariate Modeling of Hydrologic and
Other Geophysical Time Series
Searching for More Physically Based Extreme
Value Distribution in Hydrology

Statistical Procedures for Estimation of Flood Risk at Gauged Sites

ymposium on Optimization Techniques for Managing Groundwater and Stream-Aquifer Systems The Orinoco and the Amazon-Hydrology.

Sedimentology, Geochemistry, and Ecology of Large Tropical Rivers Transport Processes of Excessive Sediment

Treatment of Evapotranspiration, Soil Moisture Evolution, and Aquifer Recharge in Watershed Models

Water Quality Analysis of Impoundments

California Current Chemical Tracers and Global Circulation Modeling Diagenesis in Deep Sea Drilling Cores El Niño of 1982-83

Ocean Sciences (O)

Geochemistry of Estuaries Geochemistry of Hydrothermal Plumes in Vicinity of Mid-Ocean Ridges

Ocean-Glacier Interactions (jointly with Hydrology) Rossby Waves and Eddies in the Eastern

Parts of Ocean Basins Sedimentation Patterns in Tectonics in Active Continental Margins (jointly sponsored with Tectonophysics) Sub-Sealed Disposal of Nuclear Wustes: Site

Assessment The Response of the Upper Ocean to Very Strong Wind

Evalution of Oceanic Lithosphere (cosponsored by Tectonophysics and Volcanology. Geochemistry, and Petrology) Rio Grande Rift (cosponsored by Tectonophysics and Volcanology, Geochemistry,

and Petrology) Lateral Heterogenesis in the Mantle Tomograph

SPR: Aeronous (SA) **EUV-VU Airglow**

Lower Thermosphere-Upper Mesosphere

SPR-Cosmic Rays (SC) IMP 7 & 8: Correlative Studies Over the Solar Cycle, Including Correlative Studies With Other Spacecraft and/or With Ground Data (poster session) (cosponsored by SPR: Interplanetary Physics and SPR:

Magnetospheric Physics) IMP 7 & 8: (cosponsored by SPR: Interplanetary Physics and SPR: Magnetospheric

SPR-Magnetospheric Physics (SM) Aurora and Substorms (poster session) Comparative Planetary Magnetospheres and Comparative Auroral Phenomena Geomagnetic Tail and Boundary Layer (post-

Magnetospheric Currents and Fields (poster Numerical Simulation of Space Plasmas (post-

Special Call for Papers on all Subjects Waves, Instabilities, and Turbulence in Space

Plasmas (poster session)

SPR-Solar and Interplanetary Physics (SS) AMPTE Theory and Predictions Solar Wind Interactions With Comeis, Venus, and Titan

Active Tectonics Franciscan Geology of the San Francisco Bay Area: The Nanoplate Tectonics of the

AGU Fall Meeting Site Tectonics and Sedimentation in Active Continental Margins (jointly sponsored by Ocean

Volcanology, Geochemistry, and Petrology (V) Calderas and Associated Volcanic Rocks (Krakatau Centennial)

Cascades Volcanism and Implications for Geothermal Resources Ocean-Ridge Basaltic Volcanism (Laki Bicen-

Structure and Dynamics of Hawaiian Volca-

Other Special Sessions

Sciences)

Mineral Physics
If one of the following fields is covered in the broadest sense, regardless of the section to which your paper is submitted, please add on your abstract "For Mineral Physics Session" under number 5 of the submittal information: (1) physical measurements on minerals, (2) calorimetry, (3) high-pressure mineralogy, (4) defect structure studies, (5) mineral and solids equations of state, (6) quantum mechanics of solids, (7) spectral mineralogy, or (8) electrical measurements on minerals.

Session Highlights

Geodesy will be hosting special sessions this fall on the results from the earth-orbiting satellite LAGEOS (Lasen Geodynamics Satellite). Summaries will be presented by the major investigators dealing with earth rotation, station abstract to Fall Meeting, ACU, 2000 parameters and baselines; ocean tide parameters. Avenue, N.W., Washington, DC 20008.

ters, mass and gravity field of the canh, of evolution, and geophysical interpretation There will also be sessions devoted to ansa dynamics, gravity data analysis, modeling tidal effects, timing, and precision orbids

Hydrology (11) Charler-Ocean Interactions (jointly sponsor

mination.

by Hydrology)

A special session on glacier-ocean intertions will be convened jointly by the Ocean Sciences and Hydrology sections. Papersan solicited that address topics on the intend processes between glaciers or glacial keint oceanic environment. Topics of interestic clude but are not limited to calving of ide ter glaciers, thermodynamic interaction be tween marine ice shelves or icebergs ands sequent occanic modification, and ichen drift. Invited papers will give overview cent studies and new developments in the area. Abstracts, in standard AGU forms. should be submitted no later than August to either of the session cochairmen: Autre G. Fountain, Project Office-Glaciolog, St 850, USGS, 1201 Pacific Avenue, Tacoma WA 98402, or Edward G. Joscherger, US University of Puget Sound, Tacona, WA 98-116. In addition, send the original and copies of the abstract to Fall Meeting, & 2000 Florida Avenue, N.W., Washington, I 20009

Instream Flow Requirements for Fish: Medodologies, Implementation, and Impar-

Recent federal and state legislation has guaranteed that fish production must be or sidered in the development of water resources. This renewed interest in fish man agement will affect significantly, in many ations, the amount of water available for consumptive water uses. Numerous tede niques have been suggested for establishin instream flow requirements, ranging from hydraulic models for streamflow to fish ha tat models. Less research has been direct toward other significant issues of instream flow maintenance such as evaluation of the economic impacts of these instream requir ments on other users, their economic bene fits, and flow estimation techniques that in cate the frequency with which these require ments affect other users.

Papers are solicited that explore techniq used to establish instream flow requirem the economic and physical interactions of the requirements among water users, and $p^{\alpha\alpha}$ dures that incorporate low flow frequency timates into requirement analysis. Papers a dressing the conceptual framework for est lishing instream flow requirements, model calibration and verification, case studies, and related topics are also welcome. Abstracts # standard AGU format, should be seat by gust 31 to Richard Palmer, Department Sivil Engineering, FX-10, University of Washington, Scattle, WA 98195. In addit send the original and two copies of the ab stract to Fall Meeting, AGU, 2000 Florida's entie, N.W., Washington, DC 20009.

Multivariate Modeling of Hydrologic and Other Geophysical Time Series

This special session is sponsored by the Surface Runoff Committee of the Hydrolog section. The purpose of this special session to bring together individuals from different disciplines to discuss the state of the art and new developments of stochastic description and/or modeling in time and/or in space of multiple time series of hydrologic and geo physical phenomena.

Quite a number of models and models techniques have been proposed for representing univariate and multivariate disest ries with applications in hydrology and good physics. However, even when modeling super time series there are still a number of unit solved or controversial questions that men further studies and discussions. This similar is compounded when dealing with multiple time series. As the models attempt to hoor porate more statistical features of the history cal time series, the number of parame creases, the mathematics of the model be comes cumbersome, the identification and estimation procedures are more difficult, be testing of goodness of fit of the models is more complex, and the problem of how to deal with various types of uncertainted plants

Possible topics for this special session clude multivariate model identification is a niques, parameter estimation protedures, model testing and validation techniques, crete and continuous models, ARMA and non-ARMA models, Gaussian and non-ARMA models, Gaussian and non-ARMA models, Gaussian and non-ARMA models, Gaussian and non-ARMA models. non-ARMA models, Gaussian and models in models, models with periodic and not periodic parameters, aggregation and dispersion techniques, sensitivity analysis modeling of uncertainties, Bayesian and Bayesian techniques, models for transfer information, models for detection of charges and models for data generation and local and

and models for data generation ing.

Abstracts, in standard AGU formal, should be sent by August 15 to Jose D. Salas, Departies and of Givil Engineering, Colorado State University, Fort Collins, CO 80528. In addition, send the original and two copies of the toon, send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida, abstract to Fall Meeting, AGU, 2000 Additional Collins and Collins and Collins abstract to Fall Meeting, AGU, 2000 Additional Collins and Collins and

tional information can be obtained from J. D. Salas (telephone: 803-491-8460 or 803-491-

Searching for More Physically Based Extreme Value Distribution in Hydrology

There is a great need in hydrology for extreme value distributions that incorporate more of the physics of the underlying processes. For floods, this will allow the hydrologist to make better use of the scarce data which is usually available for streamflows and to attack the problem of ungauged catchments with a better approach than regional A special afternoon session will be dedicated to this problem. The topics to be covered

will be scale and similarity in flood frequency response, derived distributions for ungauged calchments, inhibition phenomena of flood peaks, etc. A comparison session in the afternoon will discuss the most recent statistical techniques for estimating flood risk. A panel discussion chaired by John Schaake will follow the after-

search on both areas of flood estimation will be presented. Both sessions are under the auspices of the Surface Runoff Committee of the Hydrology section. For more information on this session please contact Juan B. Valdes, Room 48-331. achusetts Institute of Technology, Cambridge, MA 02139 (telephone: 617-253-2117). The original of the abstract and two copies, in standard AGU format, should be sent to Fall Meeting, AGU, 2000 Florida Avenue,

N.W., Washington, DC 20009.

noon session in which new avenues of re-

Statistical Procedures for Estimation of Flood Risk at Gauged Sites

During the last 5 years, research has produced many new and improved statistical techniques for estimating flood risk and various qualities of the flood-flow distribution at gauged sites. This session will review these new ideas and Bulletin 17 as revised in September 1981. Topics should include advantages of regionalization, regional skewness, empirical Bayes estimators, probability weighted moments and the Wakeby distribution, measurement error and its impact, nonparametric procedures, and the use of historkal flooding information. A companion session in the afternoon will examine the warch for more physically based extreme val-ue models in hydrology. The day will close with a special panel discussion chaired by John Schaake, Jr. Abstracts, in standard AGU farmat, should be sent by August 15 to Jery R. Stedinger, Hollister Hall, Cornell University 5, Ithaca, NY 14853. In addition, send the original and two copies of the abstract to Fall ng, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009.

Symposium on Optimization Techniques for Managing Groundwater and Stream-Aqui-

Groundwater has been a largely unmanaged resource. Consequently, many areas are encountering problems of excessive local drawdown, reduced streamflows, and groundwater contamination. Currently. groundwater simulation models are used to splore management alternatives to solve these problems. In the future, combined use of groundwater simulation and optimization techniques of mathematical programing may prove to be a tremendous aid to managing groundwater resources. Such management models may be used to manage aquifer pumping and injection systems, to optimally allocate water in a stream-aquifer system, to manage groundwater quality, or to inspect the influence of institutions upon patterns of

regional groundwater use. This symposium on optimization technques in groundwater management is sponsored by the Groundwater Committee. Ab-Mracts, in standard AGU format, should be sent by August 31 to Steven M. Gorelick, U.S. Geological Survey, Mail Stop 21, 345 Middle-field Road, Menlo Park, CA 94025. In addition tion, send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009, More information can be obtained by contacting Steven M. Gorelick (telephone: 415-323-8111 etc. 2141) and Avenue General Page 15 or ext. 2141) or Manoutch Heidari, Kansas Geological Survey, Lawrence, Kansas (telephone: 913-864-5672).

The Orinoco and the Amazon: Hydrology, Sedimentology, Geochemistry, and Ecology of Large Tropical Rivers

Significant proportions of the Orinoco and imazon basins are likely to be modified drasically during the next several decades by human activities. Deforestation, hydroelectric and other water-resources developments, and pollution from pulpwood processing, mining. heavy industries, and refineries will change the nature of the river flows, the solid and solved materials they transport, and the biological communities they sustain.

Not much is known about these two rivers. A few long records of river stage exist, but aream-gauging programs were initiated less than 20 years ago, so streamflow records are short and very few data are available on the discharge control of the discharge con discharge of dissolved and solid materials.

Systematic studies of organic transport, nutrient cycling, and biological activities of these rivers were undertaken only recently. These short records and the results of recent or ongoing studies constitute the only basis for documenting the characteristics of these rivthe time of the meeting. ers under nearly undisturbed natural conditions and serve as baseline data against which

to measure future changes. This program is organized to focus attention on scientific studies presently underway on the Rio Orinoco and the Rio Amazonas. A one-half day session of invited papers will be followed by sessions of contributed papers sponsored jointly by the Hydrology and Ocean Sciences sections. Anyone conducting studies on these rivers or on the coastal regions influenced by their flows is invited to submit an abstract of the results of the research for consideration in the program. Abstracts, in standard AGU format, should be sent by August 15 to Carl F. Nordin, Jr., U.S. Geological Survey, Box 25046, MS 413, Denver Federal Center, Lakewood, CO 80225 (telephone: commercial, 303-234-2320; FTS. 234-2320). In addition, send the original and two copies of the abstract to Fall Meeting. AGU. 2000 Florida Avenue, N.W., Washington, DC 20009.

Transport Processes of Excessive Sediment

Much sediment transport theory is based on low and moderate sediment concentrations and may not be applicable for excessing sediment loads. The Erosion and Sedimentation Committee of AGU is sponsoring a symposium to review the state of the art for excessive sediment loads.

Some of the subjects already accepted for presentation include a comparison between research on hyper-concentrate sediment load n the People's Republic of China and the United States, excessive sediment loads during the Mount St. Helens episode, pipeline ansport of slurries, and an overview of the American Society of Civil Engineers Task Force on the effects of high sediment concen-

trations on velocity profiles and transport. Submission of additional papers dealing with the general area of transport processes of excessive sediment loads is encouraged. Abstracts, in standard AGU format, should be sent by August 15 to Walter F. Megahan, Forestry Sciences Laboratory, 316 East Mynle Street, Boise, ID 83702 (telephone: commercial, 208-334-1457; FTS, 554-1457). In addition, send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009.

Papers presented at this session may also be published in Water Resources Research. Speakers who would like to have their papers considered for publication should provide a completed manuscript to Walter F. Megahan at

Watershed Models

The session's invited and contributed papers will explore the manner in which the bydrologic phenomena of evapotranspiration, soil moisture evolution (including interflow) aquifer recharge, and aquifer return flows are treated in current (small) watershed and/ or river basin models. Papers addressing the physical or conceptual basis for the treatmen of the hydrologic components, the detailed structure of the mathematical models, the validity of the approaches taken, the case of calibration of the subsurface parameters, the experience in use of the models, etc., are welcome. Abstracts, in standard AGU format, should be sent by July 29 to H. J. Morel-Seytoux, Department of Civil Engineering, Colo rado State University, Fort Collins, CO 80523 (telephone: 303-491-5448 or 303-491-8549). In addition, send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Avenue, N.W., Washington, DC

A session will be devoted to the analysis of vater quality in impoundments and river-run lakes. Among the topics of interest will be (1) mathematical modeling of reservoir water quality, including eurrophication, bacterial pollution, and toxic contamination; (2) the role of suspended solids in determining the water quality of impoundments and river-run lakes; (3) characterization of diffusion and dispersion in impoundments; and (4) the def-

Other topics related to aspects of water quality peculiar to impoundments and riverrun systems (in contrast to natural lakes) will

Abstracts, in standard AGU format, should be sent by August 15 to Steven C. Chapra. Environmental Engineering Division, Civil Engineering Department, Texas A&M Uni versity, College Station, TX 77843. In addition, send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida

SPR: Interplanetary Physics (SS) AMPTE Theory and Predictions The Solar and Interplanetary Physics and the Magnetospheric Physics sections are co-

reatment of Evapotranspiration, Soil Moisture Evolution, and Aquifer Recharge in

enue, N.W., Washington, DC 20009.

Water Quality Analysis of Impoundments

inition of cutrophication for reservoirs.

also be considered.

Avenue, N.W., Washington, DC 20009.

sponsoring this all-day special session. The surpose of the session is to increase awareness of the AMPTE science objectives and to expand the base of relevant theoretical work n anticipation of the launch of the Active Magnetospheric Particle Tracer Explorers mission in August 1984. (For more information on this mission, see Krimigis et al., Ea., p. 843, November 9, 1982.) Invited speakers will discuss the interaction of large plasma releases with the solar wind and the transport of ions through the magnetosheath, the magnetopause, and within the magnetosphere.

Contributed papers are solicited, particularly in the areas of ion transport through the bow shock, magnetopause entry, magnetospheric transport, and wave excitation in mixed hotcold plasmas. Papers presented at this session may also be published in the Journal of Geophysical Research. For additional information, olease contact S. M. Krimigis (telephone: 301-953-7100). Abstracts should be directed to the SPR:SC/SS section and should clearly indicate that they are for this session. Please send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Av-

1,.

Tectonophysics (T)

Tectonics and Sedimentation in Active Continental Margins (jointly sponsored by Ocean Sciences)

This special session, jointly sponsored by the Ocean Sciences and Tectonophysics sec-tions, will focus on new work dealing with the role of sedimentation processes in response to rectonics in active margins. Correlation of depositional systems to tectonics, diagenetic changes in response to tectonic processes. sediment variability in active margins and their causes, sediment deformation during deposition, and regional patterns of sedimentation are some of the topics to be included in this session. Abstracts, in standard AGU format, should be sent by September 14 to George deV. Klein, University of Illinois at Urbana-Champaign, 245 Natural History Building, 1301 W. Green Street, Urbana, H. 61801-2999. In addition, send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009. For more information, contact George deV. Klein (telephone: 217-333-2076).

Meetings tout on p. 4347

Sample Abstract

Technique for the Preparation of Abstracts

F. R. S. T. AUTHOR (School of Oceanography, Hydro University, Watertown, Mass. 02172) S. C. N. D. AUTHOR (USGS, Woods Hole, Mass. 02543) (Sponsor: I. C. Alvin)

Follow this example in typing the abstract. The printing plates will be prepared by photographing the abstracts exactly as they are received, except that abstracts exceeding the maximum length (18 cm) or width (11.8 cm) will be cut to conform.

Use a good typewriter with a ribbon in good condition. A carbon ribbon gives the best results. Please use type of about this size. Use 12 pitch. There will be a reduction of 50% for the printed abstract volume.

Follow these guidelines:

(1) Type title in capital and lower case letters except where all capitals are standard.

Underscore entire title. (2) Leave one line blank after title.

(3) Type names of authors in all capital letters, with affiliation and address in capital and lower case letters. Do not leave blank lines between authors. (4) Underscore the name of author who will

present paper. (5) If no author is an AGU member, type sponsor's name in capital and lower case letters.

(6) Leave one blank line after author block. (7) Neatly drawn in symbols or Greek letters are acceptable. Use India ink.

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Abstract Deadline: September 14 Mail original and two copies to Fall Meeting

American Geophysical Union American Geophysical Union 2000 Florida Avenue, N.W. Washington, D.C. 20009

(Krakatau Centennjal)

Meetings (cont. from p. 433) Volcanology, Geochemistry, and Petrology (V) Calderas and Associated Volcanic Rocks

The origin of calderas and their relation to pyroclastic volcanism was first brought into focus by the catastrophic eruption of Krakatau in 1883. One hundred years later, much work is concentrating on the history of caldera-forming volcanic sequences, caldera-colapse mechanisms, the internal arriching of alderas, and perrologic evolution of calderarelated igneous rocks. These and other topics of volcanic calderas will be the subject of a centennial symposium at the AGU Fall Meeting; contributions are welcome. Please send the original and two copies of the abstract to Fall Meeting, 2000 Florida Avenue, N.W., Washington, DC 20009. For further information, contact the convenors: Stephen Self, Department of Geology, University of Texas. Arlington, TX 76019 (telephone: 817-273-2987); Grant Heiken, Geosciences Division, Los Álamos Scientific Laboratory, Los Alamos, NM 87545 (relephone: 505-667-8477); or Peter Lipman, U.S. Geological Survey, Box 25046, MS 913, Denver, CO 80225 (telephone: 303-254-2901).

Cascade Volcanism and Implications for Geothermal Resources

The Cascade volcanic arc in the northwestern United States has been the target of intense multidisciplinary geologic and geophysical study in recent years, with major foci on geothermal-resource potential and volcanichazard amalysis. This special session will provide both broad summary overviews of recent work and also report on new detailed studies. Convenous are Patrick Muffler, MS 90C, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025 (telephone: 415-323-8111, ext. 4151), and Wendell Duffield, U.S. Geological Survey, 2255 North Gemini Drive, Flagstaff, AZ 86001 (telephone: 602-765 7205). Send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009.

Ocean-Ridge Basaltic Volcanism (Laki Bio-

The eruption of Laki volcano on Iceland in 1783 is the most voluminous basaltic eruption of the historic record-25 km3. This special session, 200 years later, will focus on petrologic and structural features of ocean-ridge okanism, both in Iceland and worldwide. Especially timely would be to compare the subacrial and submarine morphologic leatures of rift-zone volcanism. For further in formation, contact Haraldur Sigurdsson, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI 02882 (telephone: 401-792-6596). Send the original and two copies of the abstract to Fall Meeting, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009.

Structure and Dynamics of Hawaiian Volcanues

Recent geologic, geophysical, and petrologic studies of Hawaiian volcanism, with special emphasis on the 1983 eruption of Kilauea. For information, contact Robert Decker, U.S. Geological Survey, Hawaiian Volcano Observatory, HI 96718 (telephone: 808-967-7328). Send the original and two copies of the ab-stract to Fall Meeting, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009.

Meeting Reports

Valles Caldera Workshop

A Continental Scientific Drilling Project (CSDP) Workshop, attended by 87 scientists, focusing on the Valles caldera was hosted by the Department of Energy and the Los Alamos National Laboratory, on October 5-7, 1982, in Los Alamos, New Mexico. The caldera, a large, Quaternary magmanydrothermal system, lies at the intersection of the Rio Grande vift and the Jemez lineament in north-central New Mexico and is a prime site for the first deep drill holes.

One major objective of CSDP is to develop a broad scientific understanding of the mots of an active hydrothermal system associated with recent igneous intrusion. Surface geo-logical, geophysical, geochemical, and hydro-logical data, along with information from shallow exploratory drillholes, will be used in the process of interactive development and testing of models and hypotheses for such systems. Ultimately, deep drilling will be essential to provide direct sampling of fluids and rocks at depth and to measure directly the critical in sitt physical parameters. Thus, deep drilling research becomes an integral and necessary component in the synthesis, refinement, and verification of three-dimensional models of hydrothermal-magina sys-

tens and processes.

The Voltes caldera was selected as an attractive site for deep drilling because (1) the regional and local geology, geophysics, and geochemistry have been well studied; (2) lithologic, geochemical, and thermal data have been obtained from many geothermal boles.

drilled to depths as great as 4.5 km; (3) liquid and possible vapor-dominated hydrothermal systems occur; and (4) geophysical anomalies suggest magma or interstitial melt at depth.

Key recommendations from this workshop include (1) the need for drilling several intermediate-depth holes (1000 m) prior to drilling a deen hole to enhance knowledge of the thermal regime at Valles, (2) the need for continuous coring in any CSD holes, and (3) the requirement to determine unconivocally whether magma exists beneath the caldera. The recommendations and the rationale for

Geophysics Working Group

Participants in the Geophysics Working Group of the Valles Caldera Workshop considered two relat-What is the evidence for interstitial melt un-

der the Valles caldera? 2. What critical experiments should be permed to determine the presence of melt under

The discussion group felt that presently there is Insufficient evidence to say unequivocally that there is interstitial melt under the caldera. However, evitlence in hand supports the thesis that a melt zone might exist at relatively shallow (lepth (<12 km) beneath the surface.

ninary geophysical evidence in support of melt is exter

 Seismic analysis based on chemical explosions nated near Farmington, N.M., shows both S wave and amplitude attenuation as well as P wave delays and telescismic frequency changes suggesting alles beneath the caldera.

2. The lack of earthquakes under the caldera in ison with an otherwise higher regional seismicity is evidence for a change in material behavior in the rocks below the calder

3. An upper crustal seismic transmission anoma ly exists under the resurgent dome in the caldera.

4. Gerhard Suhr's midcrustal seismic analysis 5. An electrical conductor exists at 10-12 km be-

low the caldera and is coupled with a regional elec-6. The caldera rests on an area of very high heat

7. The temperature gradient analyses of Swanberg suggest a magmatic heat source.

8. The gravity analyses of Cordell, Seager, and

Wilt suggest an anomaly. The very high temperatures (320°C) at the base of the HDR Fenton Hill holes and the direction of the measured gradients suggest a major heat source. Perhaps the most compelling evidence concerns the recentness and long history of volcanism. together with geological arguments, and thermal

The Working Group felt that future geophysical work should concentrate first on completion of the reconnaissance investigations current, then initiate high resolution geophysical research concentrating on the upper 10 km of the crust. This high resolu tion phase of research should focus on six topics

 Intermediate-depth drilling. Several inter-mediate-depth holes should be drilled in and around Valles caldera to obtain additional thermal

gradient measurements to be used for understanding the thermal regime in thermal modeling. Cores dd be obtained from the holes to aid in relining the geology. Holes should be logged to obtain other physical properties useful in modeling (e.g., density

2. Thermal modeling. Additional detailed thermal modeling using all available geologic and geo-physical constraints is needed. Modeling should endeavor to determine the vertical extent of the uppe hydrothermal convective system and model the

deep crustal thermal regime.

3. Seismic research. Additional seismic studies should be designed to focus on the three-dimensional structure of the upper 10 km of the crust near the caldera.

4. Electromagnetic research. High spatial resolution electromagnetic studies are needed to delineate the crustal conductive anomalies in an effort to

map the known near-surface hydrothermal system and the suspected deeper regions of melt.

5. Gravity modeling. Detailed gravity modeling using all available geologic and geophysical comstraints is necessary to strip the effects of the Pha-nerozoic cover and facilitate modeling of the deep crustal structure beneath the caldera. Such modelng may yield additional bounds on the suspected s

6. Downhole geophysical sensors. A variety of phole geophysical high temperature sensors should be developed to be used in available holes. and results should be coupled to surface geophysical

Geochemistry Working Group

The question addressed by the Geochemistry Working Group was, What is the nature of the hy hermal systems created when a silicic magnet body is emplaced beneath the Valles caldera? To answer this question, clata must be collected that do fine the hydrothermal systems with respect to Iluid chemistry, geometry, and solid phase composition. Stated another way, What processes produce the various systems associated with the Valles caldera?

To pursue these data, we recommend drilling five exploratory holes 1000 in deep (see Figure 1) to earn more about the nature of these hydrothermal systems: their recharge, discharge, permeability, and associated phase chemistry. pecifically, we want to learn more about the following points (numbers refer to the numbers in Figure 1).

 The thermal regime in the southwest ring-fracture zone to determine if it is a discharge zone and to discover more about differences in fluids and alteration phase assemblages in ignimbrite, carbon-ate, and the Precambrian rocks. This hole could be located near the youngest moat rhyolites in the caldera and thus satisfy one objective of the Geology Working Group.

2. The intersection of the northeast tracture zone and the central grahen faults to determine if this area is a recharge zone for the deep system 3. The nature and degree of communication, including wall rock alteration, between the suspected vapor dominated zone and deeper hydrothermal

systems in the Sulphur Springs area. Indications are that the boundary between these zones moved down 4. The northeast extension of the hydrothermal system into the Jaramillo Creek area along the cen-

tral graben faulis Our objective for a deep hole is to study a com-

plete sequence of meramorphic events (I) & of a vapor dominated system and deeper holog mal system with associated recharge and uples mmeralization, and (3) depth to and position heat source. With the data available now, tong tion of hole 3 will lead to investigation of depe metamorphic systems extending into the Proof an and will define their connection studies, chemically with the shallower hydrothemals. This objective supports the Drilling Technolog Working Group recommendation to core con ously to the depth desired. Hole 3 present at opportunity to study completely the mechanical indication mechanical indication are used as alteration assemblages) and deeper more diffusionally controlled melatom and their ultimate relation to the deep heares

Geology Working Group

CSDP may provide the first sampling of $\omega_{\Delta L}$ pluton beneath a caldera complex. From thepespective of geology, these samples will add will owledge of magmatic and crustal column to points describe the need for general and regest studies, values of deep sampling, need for ones, ples, and a choice for the deep-drilling location within the Valles caldera.

1. We need a synthesis report on caldera is and for regional geologic studies. Maximum si-tific value of CSDP will occur only if results of drilling can be interpreted adequately. Interpre tion requires knowledge of the regional geokgi-ting for deep drill holes and an adequate push model based on studies of comparable localist deep sampling of magna-hydrothernal system an active caldera complex, the predictive mode must be based on other active calders and on is sil" caldera complexes exposed by crosion. The an extensive literature on both active and fould dera-geothermal systems, but an adequate опр hensive summary of these systems is lacking. portant first goal for this phase of CSDF must the preparation of such a summary; if the Value caldera is a drilling target, its deeper feature should be anticipated in terms of other "type of ra systems. The summary document may sent basis for selecting the best CSDP location formal of an active hydrothermal system.

Earlier research on well-exposed fossil calded terns is an important basis for extending the sort tilic value of CSDP and a strong argumen forth drilling in an active caldera system. Mineralizable alteration, and thermal aureole developmental triost active in the last stages of caldera magna lution. Older exhumed caldera systems are on printed by these terminal events. Deep driling netive caldera system may clarify an ignouse thermal history that might then be ext

economically important calderas worldwide. For the Valles caldera, the relevant geologic framework includes Precambrian rocks of the miento Uplift to the west, overlying Paleotok's ments, and Cenozoic sedimentary and igne to the cast that aid in understanding dev of the Rio Grande rift with its associated dep al basins east and southeast of the Jemez Mount

We need deep samples from an active of system. The expense and effort of deep drilley be best repaid if drilling is designed to emphasiunderstanding of geology at depth. In Valence ra, there is knowledge from drilling at Fenon Hi



Fig. 2. (Left top) Exposed in downward succession in roadcut are two members of Valles caldera, N.M., rhyolite: (1) vitrophyric blocks of the basal part of Banco Bondo. Jound at the base of the uppermost ash bed in the El Cajete section give an age of years B.P.; the overlying Banco Bondo Maribas in the El Cajete section give an age of the propermost ash bed in the El Cajete section give an age of the control of the propermost ash bed in the El Cajete section give an age of the propermost ash bed in the El Cajete section give an age of the propermost ash bed in the El Cajete section give an age of the propermost ash bed in the El Cajete section give an age of the propermost ash bed in the El Cajete section give an age of the propermost ash bed in the El Cajete section give an age of the propermost ash pro years B.P.; the overlying Banco Bonito Member is about 0.05 Myr old. (Top right below left) Participants of the Valles Caldera Workshop examine ruins of the Sulphut Spirit sort in New Mexico, where tourists bathe in waters from hot springs and mud pols with the control of the springs and mud pols with the control of the springs and mud pols waters from hot springs and mud pols waters. sort in New Mexico, where tourists bathe in waters from hot springs and mud polsety of thermal features occurs fumaroles, hot springs, mud pots, and gaseous cold spring. Temperatures in the springs range from ambient to boiling, he may be less than sufficient to the springs of about 200°C. (Bottom right) Soda Dam, near Jemes, Springs, N.M. The travertine dam was deposited by thermal waters that discharge from straind of the Jemes fault zone. Waters (there are at least 10 springs and seeps in this and B are practically identically to those from the deep fluid within Valles caldera.

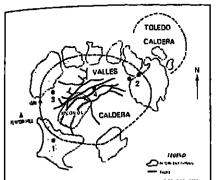


Fig. 1. Detailed map shows approximate surface outline of Valles caldera and resurgent domes. Numbers refer to suged locations of intermediate-depth poles suggested by the Geochemistry Working Group (not necessarily endorsed by the workshop). See text for complete

he caldera and from drilling in the resurgent dome the caldera. Depths of 4.4 km and temperatures of ~330°C were reached. Outflow tuffs, caldera fill, older Cenozoic volcanic rocks, Cenozoic and ozoic sediments, and Precambrian basemen were sampled. Conventional drilling yields much in formation; the underlying pluton margin remains unknown. Features of the intrusive auteole are un-

Down-hole geophysical studies and stress-relaxaion research can be made on oriented core. De-

tailed sampling must be a major goal of CSDP. 3. We must collect deep core san of deep samples must be a major goal of CSDP. Currently available sampling technology should be used extensively early in the CSDP drilling schedale. Cured exploratory holes will answer many ques tions about intra-caldera takebed and volcaniclastic nratigraphy, detailed magnetostratigraphy (the Valles caldera already provided the type locality for the brief Jaramillo event), and Centroic tectonism. Greater emphasis, however, must be on adequate deep sampling, where the greatest rewards lie. An werall geologic goal of CSDP must be collection of these unique, deep samples. Preliminary explor-atory drillholes can be cored throughout, but the payback from deep holes will be best by drilling to lepth as rapidly as possible and then concentration

4. Siting of CSDP deep holes: A geologic per

specific based on Valles caldera. The value of CSDP rep drilling is based on exploration of deep geologic features. Ability to reach cleep magnia-relate features, in particular the pluton margin, must be the major emphasis. One criterion that might help to site a deep hole is occurrence of the votingest ve canic centers. The young mont-zone silicit clumes of he Valles caldera are appealing targets for drilling healties. Besides drilling near the most recent copiese pathways, a locality near one of these oung domes will help to investigate deep features ong the ring fracture that hounds caldera collapse. such fracture systems can be seen in older, d ed calderas to be major pathways for hydrotherma teration and mineralization. Drilling "inhoard" of ering fracture near one of the young silicic domes could provide a sample of active processes along this vital fracture system. The location of this could satisfy the drilling objectives of the Geothemistry Working Group. As a second priority, another deep hole "outbrard" of the ring fracture syson would provide samples from a nearby but relawely stable section of volcanic deposits and country ock. Drilling near one of the youngest silicic domes able locably in the Valles calders from walue for CSDP and also because of the existing data base for areas outside the western caldera rim featon Hill) and in the resurgent donic (Union Oil's geothermal drilling program).

ਮਾਂlling Technology Working Group

Existing drilling technology is adequate to drill reholes in the Valles Caldera to temperatures of 00°C. This judgement was reached after reviewing Perience gained in development of the Union collernal Baca site and the Los Alantos National aboratory Fenton Hill HDR site. This experience arcred all aspects of drilling in volcanic, sediments 7), and crystalline basement rocks and at substantial temperatures (~340°C) and depths (~4570 m). Continued drilling into deep basement following operations needed to study the shallower hydrother mal system would be both difficult and costly. We

recommend drilling separate holes to investigate each of the two thermal regimes. Drilling experience indi are inadequate and that coring, either total or inter-nintent, is required. A coring bit developed for the HDR project may allow both reasonable drilling rates and ability to core continuously, especially in the sedimentary sections. Of particular interest is the symbols that could be developed between cor-ing and downhole measurement. g and downhole measurements. After core is tak-n and retrieved, the bit is pulled back some chosen distance, and a sequence of logging tools is run through recently cooled openhole region. This sequence allows great economy in use of the drill rig and an ongoing understanding of the region drilled. In addition, cooling allows use of conventional logging tools and techniques that could not run at in slut temperatures.

As in the JOIDES program, our primary goal is obtaining samples and measurements; drilling methods should be tallored to optimize this goal. Marke, and a sequence of logging tools is run

Drilling technology should facilitate sample tore) collection and borehole geophysical measurements.

2. The hydrothermal system located in volcanic and sedimentary strata should be examined and deted with a borehole terminating in the Precambrian grante (~5050

an granite (-3050 m depth).

3. This borehole sterminating in the Precambri3. This borehole should be continuously cored.
Use of a recently developed hybrid roller cone/polyal. Evolution of a hybrid roller cone/PDC core bit.

Trans. Geothermal Res. Council. 4, 1980) is recommended. Use of this interbook of delivers. ended. Use of this incited of drilling allows geo-

physical logging through the coring bit into the open hole without removing the drill string. Sub-stantial cooling obtained by this technique allows in

of conventional logging tools. 4. High temperature basement underlying the hydrothermal system should be examined and tested with a separate burehole.

5. Basement sampling should be done on an intermittent basis with full size cores by using the coring bit described. Geophysical logging should be immediately after retrieval of the core. A method of continuous coring in which a small dianteter core is cut by a roller cone bit that has a smaller diameter center hole and is then removed by reverse circulation should be examined ("coring spit-

6. Further examination of methods for reducing maximum temperature seen by the drilling bits, the drilling string, and the measuring equipment is de-sirable. One possible method is use of an insulated drill string.

7. Certain measurements require that tools be at in situ temperature. Substantial technical development is required if temperatures exceed \$00°C.

8. Further development work on high-temperature drilling fluids, corrosion inhibitors, and lost-circulation materials will aid deep drilling operations

9. Examination should be given to high tentperature turbodrill systems and 10 methods that idapt them to existing high-performance tollerone bits. Such development will substantially re-

duce wear on the drill string.

10. Use of existing wellbores would aid technical developments. Wellbores exist at the Fenton Hill HDR site and at the Union Geothermal Baca site.

Acknowledgments

Plenary session chairmen were John Whetten and Grant Heiken. Fraser Golf and Stephen Bolivar were field trip leaders. Working group chairmen included Jamie Gardner, David Vaniman, Mark Ander, Robert Riecker, William Laughlin, Robert Charles, Fraser GotT, John Rowley, and Robert Potter. The workshop was sponsored by the Office of Basic Energy Sciences of the U.S. Department

This meeting report was prepared by Robert E. Riecker of Los Alamos Scientific Laboratory, Law Alamos, NM 87545.

HDR Geothermal Exploration

Introduction Hor devicek (HDR) is defined as that part of a geothermal anomaly where the fluids needed for production of steam or hot water are lacking. Most of the world's geothernal resource is not present in the form of natural hydrothermal systems but as HDR, Development of this resource through the use of manmade geothermal systems is in progress in several countries. The largest of these experiments, the Fenton Hill FIDR geothermal project, is funded by the U.S. Department of Energy and the governments of West Germany and Japan. This project is located a short distance west of the rim of the Valles Caldera in the Jemez Mountains of New Mexico. As the Fenton Hill experiments progressed, it became evident that the location and extent of the HDR geothermal resource in other arcas should be evaluated and that potential HDR drilling sites be located as part of a comprehensive program needed to encourient, Because the HDR resource lacks the sharp physical and chemical contrasts produced by natural fluids, it presents different exploration problems from those of conventional hydrothermal exploration. The purpose of a workshop, held in Los Alamos, New Mexico, June 21-23, 1982, was to review geological, geochemical, and geophysical exploration methods currently u for HDR recognition and resource evaluation and to evaluate new ideas for HDR explora-

Heat Flow Criteria Heat flow, because it involves direct ten perature measurements, is usually the ultimate standard for evaluating geothermal poof resolution narrows to that of choosing

drilling sites. Crustal heat flux varies between regions of relative geological stability such as eastern or midwestern North America and the more active regions like western North America where crustal temperatures are usually hot-

For stable regions J. Costain (Virginia Polytechnic Institute and State University) cited several geological settings that seemed prom-ising for HDR. These take advantage of the fact that heat flow is the product of thermal gradient and thermal conductivity; therefore, regions of low thermal conductivity can have rather high thermal gradients and hence high temperatures, at moderate depths, even though heat flow is only average. Heat flow is further enhanced if local crustal heat generation is high. Hence, two interesting HDR possibilities would be regions of normal gradient but deep, relatively insulating sedimentary rock and regions of high heat generation, such as a granitic pluton overlain by "blanket-ing" sedimentary layers.

W. Hinze (Purdue University) elaborated upon some variations where crustil heat is concentrated by a local good thermal conductor such as a salt dome, by hydrothermal circumstances culation, by residual magmatic heat, or by up-

per mantle sources where the thermal effects ave not ver diffused to the upper crust. Hinze cited thermal anomalies within the Mississippi Embayment as a possible example of "channeling" by a good thermal conductor. K. German (University of Nebraska at Lincoln) attributed high temperatures in western Nebraska to the hydrothermal circulation mechanism, as did D. Hodge (SUNY, Butlalo), to explain high bottom hole temperatures in basement rock near Auburn, New York,

Hence, from the standpoint of heat flow methods HDR exploration in older "stable" continental crust involves three criteria: (1) locating regions of relatively high heat those (2) identifying regions of low thermal conductivity, and (3) determining radiogenic heat production in basement rock.

Because of a far greater density of thei mal montalies, tectonic zones such as the western United States have enjoyed a much higher level of geothermal exploration, and many geothermal areas have been identified. Thus, an obvious HDR exploration technique cited by D. Blackwell (Southern Methodist University) and M. Smith (Los Alarmos National Laboratory) is to obtain heat flow data in the conductive haloes" surrounding known hydrothermal sites. Indeed, these areas often have sufficient numbers of "dry holes" to make them more interesting as HDR sites than as conventional sites. Steep geothermal gradients are, of course, direct indicators of igh temperatures at accessible depths, but Blackwell indicated the need tor a more reliable and easily interpreted way of using heat flow to project thermal effects to great depth Groundwater and hydrothermal water circulation add further complications, including extremely high apparent surface heat flow, but there is a growing body of experience in modeling these situations.

Further Work in Heat Flow Methods

The outlines for adequate heat flow criteria in 11DR exploration are given above. However, the panel noted that these criteria could be improved and systematized by some additional ellorts.

 1. A higher density of heat flow determinate rions would be extremely useful; it is particularly innortant to extend measurements beyoud the immediate area of a wer geothermal or UDR site in order to reduce ambiguity in interpretation of bear flow data and to mode convective hear transfer better.

2. Better communication between the academic community and the geothermal industry would be beneficial in obtaining basement remperatures and cores for measurement of asement temperature, thermal conductivity, and heat generation

3. The Decade of North American Geology (DNAG) series of maps could serve as the outlet for four additional maps: (1) temperature at top of basement, (2) basement heat production, (3) heat flow at basement surface. and (4) surface heat flow.

Seismic Criteria

the "conductive halo."

If one were to look only at the relatively small effects, due purely to temperature, or seismic velocities, then only subile variations in seismological observations would be observed. The utility of seismic methods is in determining crustal structure and thermally associated but often indirect phenomena such as the presence of fluids.

Many of the seismic methods are so well es tablished that they are almost taken for granted. W. Laughlin (Los Alamos National Laboratory) described reflection surveys that were used to characterize depth to basement at the first HDR site at Fention Hill, New Mexico. Magma bodies are potential HDR thermal sources, and S. Kaufman (Cornell University) showed how reflection profiles helped define a magma layer intruded be-neath the vicinity of Socorro, New Mexico. L Braile (Purdue University) mentioned the strong structural controls provided by seismic refraction in the Yellowstone-Snake River Plain region: these included substantial veloc ty decreases, as much as 30%, attributed to fluids. Although the fluids would not themselves be the object of HDR exploration, they could contribute to heating nearby rock in

Seismic methods are particularly well suited to locating disturbed zones that have been heated hydrothermally or by magina. K. Aki (Massachusetts Institute of Technology) noted that almost all the hot zones currently extablished as geothermal sites are characterized by deep crustal low-velocity cores. These comprise not only giant systems such as Yel-lowstone, but also the Jemez Caldera (although velocity surveys inside and outside the calders did not play a role in originally choosing this HDR geothermal site). Three-dimensional telescismic P wave delay studies have strikingly outlined several low-velocity cores that represent hot rock that provides heat both to the local hydrothermal systems and to the halo of hot but dry rock. Seismicity serves to delineate possible HDR reservoirs in a number of ways: It can locate possible intrusions such as the Socorro magma layer; on the local scale it can provide Information on stress directions as a guide to drilling. Contraly to the case for conventional

for manmade systems becasue of the danger of induced earthquakes and of water loss through active faults

Further Work in Seismic Methods

Future work in seismic HDR exploration should take advantage of those properties that are most sensitive to crack structure and pore fluids as ways to define the general form of geothermal structures: (1) teleseismic S wave structure to define three-dimensional (3-D) structure as done for P waves, (2) determination of 5 velocities. Poisson's rations. and Q^{-1} in retraction surveys, (3) controlled surface wave studies to improve resolution of V, and Q=1, (4) detailed studies of known conventional hydrothermal and HDR areas to gain experience in seismically defining these

Magnetotelluric Criteria

Electromagnetic methods, magnetotellurics (MT) in particular, are extremely useful in geothermal exploration because of the sensidivity of rock conductivity to water content and to elevated temperatures. MT can target HDR resources in two important ways. As a regional exploration method, MT can be used to map the crustal deep electrical conductor, M. Ander (Los Alamos National Laboratory) showed five long two-dimensional models developed from approximately 200 MT soundings in Arizona and New Mexico. These models indicate strong evidence for a correlation between the depth to deep electrical conductor and surface heat flow as well as with regional tectonics. One of these models, from Seligman to

Yuma, Arizona, was used in a presentation by C. Aiken (University of Texas) and M. R. Hong (University of Texas) to indicate a correlation between the depth to the deep crustal conductor and the depth-to-Carie point.
M. Ander and T. Shankland (Los Alamos National Laboratory) showed results of a correlation study of worldwide MT field data and crustal temperature obtained from surface heat flow. A pronounced result of their study was that even the most resistive crustal regions have conductivities several orders of magnitude better than laboratory samples and that this is easily explained by the presence of volunles, water in particular. Most un portantly, the data could be well represented by a straight line fit on a log versus 1/T plot indicating an excellent correlation between crustal electrical conductivity and crustal temperature, G. R. Jiracek (San Diego State University) suggested that the deep crustal electrical conductive horizon may occur where an impermeable, ductile cap traps pare fluids. beneath. Ductile flow mechanisms are thermally activated processes that involve charge defects, lattice dislocations, or atomic diffusion, all of which enhance solid state electrical conduction. If active magma injection destroved the integrity of the ductile cap, trapped fluids would escape, resulting in an overall decrease in conductivity. The final electrical signature would depend on thermal gradient, relative impermeability of the cap. extent of the pore fluids beneath, and amount of magma intrusion. Because tem perature would likely be the major variable in a given geologic province, Jiracek also felt that the depth of a conductive layer, even if caused by a ductile layer, would provide a measure of the thermal gradient. Therefore, it is likely that estimates of crustal temperature and regional heat flow can be obtained from estimates of the depth to crustal electrical conductor.

As a local exploration method, MT can be used to map the structure of resistivity changes at a potential HDR site. This requires high quality MT data and a tight MT station spacing. For both the regional and the site specific exploration, problems exist in modeling and in interpreting the field results. A. Orange (Emerald Exploration, Inc.), S. Park (MIT), and D. Chambers (Woodward-Clyde Consultants, Inc.) discussed the nature of some of the pitfalls of AfT interpretation in both two and three dimensions. MT interpretation is a complex art, even in many cases where the data appear straightforward; recognition of this complexity is a major step toward the realization of the method's full capublishes. Intense study of a wide variety of two- and three- dimensional models will provide the interpreter with valuable, critical insight. MT surveys should be planned by using this insight.

Further Work in Electromagnetic Surveys

The electromagnetics working group had several specific recommendations for further

1. In the past decade, well over 5000 MTundings have been completed in the United States. These represent an extraordinarily valuable data base for determining the deutli to the deep electrical conductor. It was aug-gested that these data be compiled in a single data base and analyzed. An international project to do this has been endorsed already by the National Academy of Sciences. This would be of value in further confirming the correlations between electrical conductivity. heat flow, depth-to-Curie point, and regional

The state of the second of the second

2. A continuous exploration program, using electrical methods, should be directed toward locating conductivity anomalies in the United States. These could be either hydrothermal or HDR systems. The distribution of heat flow and electrical properties may well be useful in differentiating the two types of

3. A major uncertainty exists in knowing how to interpret enhanced electrical concluctivities in the crust. Possible mechanisms are numerons. Although we have some measure of understanding of these effects, there is insufficient information to judge how these effects persist over time. For instance, can pore fluids persist in enhancing conductivity over geologic time at temperatures of several hundved degrees or do they form hydrated minerals and hence change rock conductivity? In addition, long-term measurements of electrical conductivities in rocks need to be undertaken at geologic temperatures and pressures to understand changes with time.

Gravity and Magnetic Criteria

There are many ways in which gravity and magnetic methods can be applied to exploration for HDR resources. Gravity analysis is well suited for mapping depth to rocks with low permeability. Magnetic methods are not usually as well suited for this because magnetic "basement" seldom coincides with geologic "basement." Gravity can be used to some minor extent in studying the nature of the sedi-mentary blanket. Both gravity and magnetic surveys are important methods for delineating both regional and local structure in the Phanerozoic and the basement. They are particularly good for locating faults, suture zones, and old rift structures. Magnetic surveys may be used to determine depths to the Curic isotherm. A shallowing in the depth to the Curic isotherm may suggest a thermal upwelling and therefore a possible HDR tar-

J. Costain, L. Glover (Virginia Tech), D. Hodge, and K. Fromm (SUNY, Buffalo) described the use of gravity data in targeting HDR sites in the eastern United States, while W. Hinze, L. Braile, R. von Frese (Pardue University), G. R. Keller, R. Roy (University of Texas at El Paso), and P. Morgan (Lunar and Planetary Institute) described gravity applications in the midcontinent United States. In these studies, gravity and magnetic data covering broad regions have been observed, compiled, and in some cases filtered to enhance particular attributes of the anomaly field. These maps are proving useful reconnaissam e tools in mapping tectonic/lithologic regimes that serve as guides to localize more

detailed geophysical and geologic studies.

In particular, gravity and magnetic surveys have helped in investigations of silicic and al-

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kalic intrusive bodies, which are potential radiogenic heat sources. Silicic intrusives are commonly characterized by gravity minima of the order of a few tens of milligals and negative magnetic anomalies. However, some plu tons studied in the midcontinent are associated with relatively high magnetite contents resulting in strong localized magnetic anomalies. The gravity signature of these high-magnetice plutous is absent or slightly

generally marked by both intense positive gravity and magnetic anomalies. In two separate papers, I. Won (North Carolina State University), C. Aiken, and R. Hong discussed the inversion of magnetic data to determine the depth to Curie poin isotherm. Aiken and Hong described how depth to Curie point estimates they made along a profile from Yuma to Seligman, Arizona, correlated with estimates of depth to deep crustal electrical conductor made along the same profile by M. Ander using MT data.

positive. By contrast, alkalic intrusives are

Further Work on Gravity and Magnetic Methods

The gravity and magnetic working group identified several areas for further work in lying gravity and magnetic methods to

 More case studies are needed. 2. Petrophysical studies are needed to obtain precise measurements of density and

magnetization of rocks of interest. Studies addressing the magnetization of rocks as a function of temperature for extended times are considered especially important. 3. Gridded filtered data sets must be gener-

4. Although magnetic maps are widely available, digital magnetic data are not. It would be useful to make such data available. 5. It would be profitable to further study the correlation between the depth-to-Curie

isotherm estimates and surface heat flow and

the depth to the deep crustal electrical con-

Geologic Methods

Geologists attending the workshop all em-phasized a multidisciplinary approach to HDR exploration. Their role is to provide the geological framework for geophysical data in regional HDR surveys and to characterize the genesis and thermal history of heat sources within geothermal areas associated with recent volcanism or older silicic plutous. The geologist's role has changed little since the Hot Dry Rock Resource Evaluation Panel (HDRAP) of the Energy Research and Development Administration defined the variety of geological surveys needed for HDR exploration and development.

Within igneous systems, which make up ost of the known geothermal resource areas (KGRA's) of the United States, the geologist's role in defining the HDR resource is substantial. To understand the extent and magnitude of hydrothermal and HDR components of an igneous system requires detailed information on the structural setting, ages, distribution, volume, and composition of volcanic units, the hydrologic setting, and chemistry of rockwater interactions within the system. The rate of fracture formation and fracture healing within these systems must be determined. All this resource definition requires drilling and careful analysis of cores, cuttings, and geophysical well logs.

Some of the most useful data sets for the geologist are those from the many wells drilled for hydrothermal development that have high temperatures but no production of fluids. By keeping records of "hot but dry" wells within KGRA's, the high-grade HDR resource may be best evaluated.

Source may be best evaluated.

Examination of regional thermal anomalies is mostly in the realm of geophysical surveys. However, the characterization of HDR reservious. voir rocks depends upon good physical and

petrologic studies.

E. Padovani (National Science Foundation) discussed the utility of petrology of xenoliths from young volcanic rocks as a tool for geothermal evaluation. It is possible to us ogic geobarometers and geothermometers to calculate thermal gradients; these serve well as supplements to measured heat flow.

A major problem in HDR resource evalua-tion is determination of changes in the stress regime and permeability with depth in a variety of geologic settings. These data are needed for identification of rock units to serve as HDR reservoir rocks.

Compilation and evaluation of existing geological and geophysical data would be easier if there were a clearinghouse for published and proprietary information. Also needed are better curatorial facilities for the preservation of drill cores and cuttings; perhaps such facilities could be established through a continental scientific drilling program,

W. Laughlin and M. Smith described the W. Laugnin and M. Smith described the process of selecting the first hot dry rock geothermal site in the Jemez Mountains, New Mexico. Of primary importance to site selection was the published data available on the extent, age, and nature of the Valles Caldera. Heat flow measurements along the western edge of the caldera, structural mapping, and a slin exploratory drill hole to the Precambit-



1983 AGU Fellows



Peter L. Bender-For his innovative work in the development and exploitation of new advanced systems for generation of precise data for a variety of geophysical applications; variations in the earth's rotational rate; lunar orbit and lunar mass distributions; tectonic plate motion; crustal movements in seismic zones; global gravity field; and precise geometric positioning.



Marx Brook-For extensive and original contributions to physics that have resulted in increased understanding of electrification and severe storm dynamics and their effect in



Harmon Craig—For sustained and diverse contributions of the most fundamental nature to the field of geochemistry.

Herbert S. Bridge...For continued contributions of the highest scientific quality to our understanding of the solar wind and its interaction with the planets of the solar system.

Frank M. Richter—For providing a better understanding of convective processes in the

and jointing within the plutonic-metamorphic

reservoir rocks was not possible and could be

determined only by drilling. Drilling slim ex-

vides many of the answers and appears to be the best local site evaluation technique; it cer-

ploratory holes, with numerous cores, pro-

tainly was at the New Mexico site.

an "basement" were key factors in site selec-tion. Determination of the degree of faulting and ioining within the above the degree of faulting Nebraska is more difficult to explain; a so be related to water flow along fractures in the Dakota group or to buried granitic per tons. More drilling into Precambrian base ment rocks is needed to evaluate the HDR geothermal resource of Nebraska, but # 10

Andrew P. Ingersoll-For his contribute

to the understanding of planetary atmospheres through the interpretation of space

Lynn W. Gelhar—For his contri

nethods to that field.

the science of groundwater hydrology a

particularly for his application of nodes

G. V. Gibbs - For greatly expanding of

knowledge of crystal structures and my

chemical characteristics of many and dise

Dennis E. Hayes-For outstanding to

butions in marine geophysics-exploration

concepts, and syntheses.

Geothermal exploration strategies used the Rhine Graben by the European Countries were presented by B. Holfers and mos National Laboratory and Gerwell Walter). These include (1) work and 66 Hodge and Fromm used heat flow, temperature gradients, and gravity surveys to search for hidden thermal anomalies in the northern Appalachian basin. Initial results indicate that variations in temperature gradi-Walter). These include (1) work on the ents are due to heat generation in granitic Walter). These include (1) work on the gneisses and schlists of Hercynian age, ites of Carboniferous age, and Paleon mentary rocks; (2) bottom-hole temperature and heat flow measurements; (3) flower gravity anomalies; and (4) tectonic analysis gravity anomalies; and (4) tectonic analysis ben and higher temperature gradient ites ben and higher temperature gradient ited through the use of, in addition those surveys described above, refraction reflection seismic profiles. MT survey and magnetic surveys, and electrical surveys plutons in the basement (similar to the anomalies described by J. Costain in the Atlantic coastal plain). Recent drilling in western New York state has indicated that not all thermal anomalies are related to buried granitic plutons; some appear to be the result of hydro-thermal circulation along faults and fractures Heat flow measurements, bottom-hole tetu-

eratures in oil and gas wells, and residual Bouguer gravity maps were the basis of a geothermal resource assessment of Nebraska by Gosnold and German (University of Ne-This indeting report was contributed by G. Heiken, M. E. Ander, and T. J. Shanking, Las Alamos National Laboratory, Las Alamos, A. braska]. Two areas within the state have high heat flow. Within the panhandle of Nebraska Los Alamos the anomalies appear to be due to updip flow 87545. to be due to



Hugh H. Kieffer—For his contributions to the investigation of planets through infrared

Michael W. McElhinny—For outstanding

ontributions in paleomagnetism and plate



science during which he has made significant contributions in soil science and in the theory of solute transport by groundwater.



Edward C. Stone-For the continued excellence of his research in cosmic ray physics and for his extraordinary efforts on behalf of his tellow scientists as Voyager Project Scien-



John G. Ramsay For revitalizing structural geology by careful quantitative studies of ningly minor features, showing how much



James R. Wallis-For research and leader-



ship in the application of statistics and sto-

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> American Geophysical Union 2000 Florida Avenue, N.W. Washington, D.C. 20009

Electromagnetics

0703 Antonias (Roles messurements in planes) QUE THERMAL BOISE CORRECTIONS DUE TO PARTICLE IMPACTS OR CHISSION SHATTER-VERNET (CRIS LA 264, Department Recharches Shattains (Description 264, Department Recharches

Spatialon, Observatoire de Parta-Naudon F92195 Hendon Principal Codes)

Sacont measurements of the "quasi-chermal" noise in a stable plasma have exhibited an additionnal local and diffuse noise below the electron plasma frequency; this has been suggested to be due to impacts or emission of charged particles as the antenna surface. To investigate this problem beyond the pravious semi-herelatic evaluations, we extend the quasi-chermal noise calculations, to extend the quasi-chermal noise sciculations, to extend anthch are not transparent to particles. We apply the vesuits for small radius apherical and cylindrical entenous in an isotropic equilibrium plasma, at fraquencies of the order of magnitude of the plasma fraquency. For antennas near the plasma de-potential, the theoretical soise consists of the usual thermal noise plus a component which has the following properties to 1) for email double-spheres entennas, it has an f-2 spectrum around the plasma fraquency; just below, it is of the seme order of magnitude of the thermal noise if the entenna length is larger than the plasma Order of magnitude of the thermal noise if the entenna length is larger. (1) for fine cylindrical entennas, it is only broadly f-2 below the plasma fraquency; just blow, it is gonatelly such smaller than the quasi-chernal soise. Fractical consequences are given for recent superisente in the solar wind and terrestrial magnitusphere (Antennas, thermal-noise, plasmas).

J. Gouphys. Ras., Blus, Paper 34(01)

Exploration Geophysics

0910 Computer applications
BUTTREMORER DIP FILTED
Bee OSIO Selenks methods
Dava Hale (Department of Geophysics, Stanford
Oniversity, Stanford, CA 96303) Jos F. Clarbout
Dip filters enable a geophysiciat to discriminate
between various salamic events on the basis of apparent
dip. The frequency-wavenumber (v, t) domain seems an
attractive domain to perform dip filtering because it
permits the application of an arbitrary transfer
function of dip. Selenic applications of dip ifirering,
however, saldow require the flexibility offered by the
(w, t) domain some may often be willing to macrifice
this flexibility to obtain Castures not possible with
(w, t) domain filters, but readily available with
tim-space (c, x) domain filters. Examples are (i) rime
and apace variability, (2) flexible treatment of
computational grid boundaries, and (3) an efficient,
recursive implementation. We describe a (f, x) domain
dip filtering method with these features.

In the derivation of a (s, x) domain filter, we first
discuss (c, k) and (0, x) domain dip filters. While not
fully possessing the advantages of a (f, x) domain
filter, these filters are an attractive combination of
two very efficient and commonly available processes:
(i) one-dimensional Butterworth filtering and (2)
one-dimensional Fourier transforms. We then derive
(f, x) domain approximations to these filters which have
the features moted above.
GEOPHYSICS, VOL. 48, NO. B

0930 Saismic methods COMERENT BOSE IN MARINE BRISHIC DATA Ken Larger (Vestern Geophysical Coupany, P.O. Box 2469, Bouston, Tt 77252) Equ Chambers, Msi Yang, Walt Lynn, and Willow Val

Ren Larour (Vesterm Geophysical Company, P.O. Box 2469, Houston, Ti 77252) for Chambers, Maí Yang, Wait Lyan, and Willon Wai

Despite significant advances in marine streamer design, seismic data are often plagued by coherant moise having approximately linear moveout across stacked sections. With an understanding of the characteristics that distinguish such noise from signal, we can decide which noise-suppression techniques to use and at what stages to apply them in acquisition and processing.

Three general mechanisms that eight produce such noise patterns on stacked sections are examined; direct and trapped waves that propagate outward from the saismic source, cable motion caused by the rugging action of the boat and tail buny, and scattered energy from irregularities in the water bottom and sub-hottom. Depending upon the machasies, society different poise patterns can be observed on shot profiles and comman-midpoint (CMP) gathers; these patterns can be diagnostic of the dominant nechanism in a given sat of date. Field data from Caused and Alaska suggest that the desinant noise is from waves scattered within the shallow sub-hottom. This type of nose, while not obvious on the shalt records, is accusally anhanced by CMP stacking. Moreover, this noise is not confined to marine date; it can be as strong as sorface wave noise on stacked lend scient for suppressing the noise while preserving signal. Since the accusaing the noise while preserving signal. Since the accusaing the noise while preserving signal. Since the accusaing the roise within shot records and common-receiver gathers or to stacked tracos. Our data mample demonstrates that although it is more costly, moveout filtering of the unstacked data is a raticularly affective because it conditions the data for the critical data-dependent processing stapp of predictive deconvolution and velocity analysis.

PRYBECS, VOL. 48, 80, 7

striking: dip rates of 90 degrees are achieved and the model shows a slight overhang of selt. These results show there is nothing in principle to prevent inversion of steeply dipping structures from surface-recorded seimic dars, including such extreme cases as

0930 Setumic methods COMPERSATION OF MARINE SEISHIC DATA FOR THE EFFECTS OF HIGHLY VARIABLE MATER DEPTH USING MAY-TRACE MODELING—A

ONJO Seismic methods
COMPRESATION OF MASINE SEIGHIC DATA FOR THE EFFECTS OF
MICHLY VARIABLE WATER DEPTH USING RAY-TRACE MODELING—A
CATE HISTORY

Brian Deat (cicius Service Company, Enorgy Sesources
Group, Tech. Center Room 9175, box 3003, Tules, OR
74[07]

Veriable water depth can cause severe degradation of
warine seismic data. This paper presents a technique
for correcting the elfects of water depth variation and
in a case history of applying the technique to a line
of data from the Philippines of shore. The line crosses
a deep submerice valley, it will be shown that when the
water depth changer rapidly relative to the cable
langth, the timing variations introduced will not be
static. They are dynamic, not static, because they
differ for different event times of a single trace. To
companies to these dynamic timing variations, a
two-stage technique was used. A ray-trace modeling
program calculated the traveltimes to several depth,
both for where the valley is present and where it is
absent. A second program used the model results to
absent. A second program used the model results to
capitate the samples on all asimic traces to the time
thay would have if the valley were not present.

The most difficult part of this project was finding a
good model. The model is composed of two parts: the
depth of the sea floor and the vallocity-depth
relationships below the sea floor. The depth of the sea
floor was setimated from the first arrivals on the
mar-offset traces of the shallowness of the normal sea
floor (shout 80 m) and the large offset between the
shot and the first group (25) m). The first arrivals
were head waves, not reflections, off the nee floor.
The reflections from the valley he to be migrated to
obtain accurate depths. The subses vallocity-depth
relations size had to be estimated from the saisonic
dots. Mowers, the results of applying the corrections
are contracted with the results of applying purely
static corrections. The static corrections else in the form
aleady of the date, more importantly they allow

recording. GEOFHYSICS, VOL. 48, 30. 7

O990 Instruments
TEX RESOLANT ACOUSTIC PULSER -- A CONTINUOUS - PREQUENCY
MAILE SEISMIC SOURCE
M.C. Rarde (Saudia National Laboratories, Gauphysics
Division -- 1541, Albaquerque, 7M 87185) R.G. Hills
A marine salamic source is described which produces a
continuous low-frequency (10-100 Hs) barmonic signal.
High scoustic power levels (**Q0t**) are reached by using
a resonant system. The seiselc source has been
successfully cested in lake and ocean environments.
Geophysical applications are discussed and
modifications are described which would a.'ow the
source to be operated in a swept-frequency mode.
GEOPHYSICS, VOL. 48, NO. 8

OS99 General or miscalizacous
AM OPDATED SOUGHER ANDRALY MAP OF SOUTH-CENTRAL WEST
AFRICA
David A. Hastings (Technicolor Government Services,
Inc., EMS Data Center, Sioux Falls, SD 57198)
A new Bouguer gravity anomaly map compiled for
veatern Africa adds data for Chena, Guinea, end
Liberia.
The new data add detail to a key part of the Eburnean
shield and assist in the development of a model of
rifting at the time of the Eburnean orogeny, 2000
million years ago. This model facindes a Framework for
the deposition of the region's mineral deposits. The
model and existing field data can be used to guide
future adversits exploration in the region.
GEOPHYSICS, VOL. 48, NO. 8

OSOPHYSICS, YOL. 48, MD. 8

OSSI General or miscellaneous
RECENT DEVELOPMENTS IS THE USE OF SURFACE ELECTRICAL
METHODS FOR OIL AND CAS EXPLORATION IN THE SOURT WHOM
Brish I. Spias (Porsely EDCOR, Denver, and Bureau of
Mineral Resources, Camberra, Australis; presently
Electromagnetic Surveys, Inc., 2161 Shattuck Avanue,
dtc. 307, Berkainy, CA 54705)
A great deal of interest has been expressed in
Mestera countries during recent years on possible
applications of surface electrical methods is oil and
gas exploration. It has been reported that these
methods are widely used in the Soviet Union, but to
date few sechnical details have been svailable. In late
1979, the author visited the Soviet Union used the
auspices of the Australia-USSR Agreement on Scientific
Gooperation, with the purpose of studying recent
developments in electrical and electromagnetic (EM)
methods. This paper presents a summary of the use and
applications of those wethods in oil and gas
emploration, and includes a number of case histories.

The methods can be broadly classified as follows:
sounding for structural mapping, sounding to measors
the geoelectric properties of the oil-bearing horison,
and indirect methods which detest the presence of a
geochesical plume or halo shows the oil deposit. The
magnetotelluria (MT) sethod and transient sounding in
the tear sons (ZSS2) are widely used for deep saunding in
the tear consecutive of a large (1000 m) square loop
carrying a 40 A rectangular waveform, and the receiver
is a militure out i located at the center. Depthe of
suploration depand upon geologic conficions, but they
are typically of the order of 3 to 4 bm.
Statiatical data, based on logsing, of the
geolactric properties of a large number of oil fields
have also been collected. There is generally an
increase in reasistivity in beth the oil-bearing horison
and coverlying Layers. The vessicivity of near-surface
lagors appears to be partially dependent upon climatic
conditions.

Experisantal induced-polarization (1) aurycys have
been carried out ov

thes saveral seconds) are unsaured. If 'snowalise are thought to be caused by spigmostic printstation located in a plus over at I fields in a greehanterity server convictions the monalise are either of the form of a wide scoonly icantered over the city of the deposit, or it is played a halo, surrounding the deposit, there is he widesce that the behavior of the I deay at very late of these priors the played and a new second of the city of distinguish IP as a new late of the city of distinguish IP as a new late of the city of the

Geochemistry

1410 Chemistry of the atmosphere
VAPOR PHASE AND PARTICULATE SELENIUM IN THE MARINE
ATMOSPHERE
Byard M. Hosher (Center for Atmospheric Chemistry
Studies, Greduate School of Oceanography, University of
Rhode island, 02881), Robert A. Duce
Particulate and vapor phase sampling has been
conducted at six locations ranging from a New England
urban location to northern and southern hemisphere
remote island sites. Particulate selenium
concentrations range from 0.3-1 ng/m³ in urban
locations to 0.06 ng/m³ in remote southern hemisphere
areas. At many diverse locations such as Spitsbergen,
Bermuda, and Mayain, particulate Sa concentrations of
0.1 to 0.3 ng/m³ are typical. Inis may represent a
northern hemisphere marine background level but more
extensive southern hemisphere sampling is necessary in
order to document any interhemispheric differences that
may exist. Vapor phase selanium typically constitutes
roughly 20 percent of the total (range 15-16 percent) at
most locations except the Paru coastal region where
copper smelter particulates influenced the
particularyapor partitioning and above the marine
boundary layer in Hawaii where roughly 45 percent of the
selenium is vapor phase. Vapor concentrations range
from 0.6 ng/m³ in urban areas to 0.02 ng/m³ at the
southern hemisphere Island of Samoa. Particulate and
vapor phase selenium appear to be produced both
anthroposenically and naturally and the ocean appears to
be an important source for vapor phase selenium. This
oceanic vapor phase may be an important factor in
maintaining the anomalous enrichment of particulate
selenium in remote regions. (selenium, vapor phase)
J. Goophya. Rea., Graun, Faper 300864

J. Geophys. Res., Green, Paper 300864 Geodesy and Gravity

1930 Rolations of gravity observations to testanics and iscolarsy
THREE-DIMENSIONAL GEOMETRY OF THE GORDA PLATE BENEATH
R. C. Jachens (U.S. Geological Survey, Henlo Park,
California 9023) and A. Griscen
The lacestatic residual gravity field over northern
California 9023) and A. Griscen
The lacestatic residual gravity field over northern
California 9023) and A. Griscen
The lacestatic residual gravity field over northern
California 9023 and A. Griscen
The locus of points of maximum elops defines a line
trending 5.60° E. From a constal point approximately
20 km south of Cape Mendocino, a point where the
buried plate boundary is inferred from segnetic and
selsmicity data. Southeast from the grows approximately
and stance of 120 km the gravity anomaly parallels the
strike of the Blacco fracture zone and the prosent
direction of relative motion between the Pacific and
southern Gorde plates. California from the form of
the anomaly yield depth serinates that fit an eastsouthout plunge of approximately 9° for the top of
the Gorde south adge. The sense of the anomaly
(hisper gravity to the south) supports the hypothesis
that a window developed in the subducted slab east of
the Ban Andreas fault and nouth of the Gorde plate.
South of the Gorde boundary, the base of the North
American plate is thus in contact with hot material
from the suthonosphore that invaded the window.
Secause the everlying North American plate has been
roving relatively south across the Corda boundary, the
North American plate is thus in central California may be
decoupled from the underlying paterial at a depth
slightly deeper than the depth to the top of the
boundary at the time the North American plate passed
over it. (Corda plate, gravity, subduction).
J. Geophys. Res., Red, Paper 180910

1970 Standards and Absolute Measurements
RESULTS FROM AN ABSOLUTE GRAVITY SURVEY IN THE UNITED

RESULTS FROM AN ARSOLUTE GRAVITY SURVEY IN THE UNITED STATES

M. A. Zumberge, J. E. Failer (Joint Institute for Laboratory Astrophysics, University of Colorado and Mational Bureau of Standards, Boulder, Colorado, 60305) and J. Gachwind

Using the recently completed JilA shoolute gravity meter, we unde an absolute gravity survey which covered twelve sites in the United States. Over a period of eight weeks, the instrument was driven a total distance of nearly 20,000 km to sites in California, New Maxico, Colorado, Myoming, Maryland and Massachusatts. The time spent in carrying out a measurement at a single location was typically one day. A measurement accuracy of around i × 10⁻⁷ a/s² (10 µgal) is beliaved to have been obtained at each of the sites. (Absolute gravity, accoleration of gravity, gravity, gravity, survey).

J. Gaophys, Res., Red, Paper 180016

1970 Standards and Absolute Heasurements
RESULTS FROM AN ABSOLUTE GRAVITY SURVEY IN THE UNITED NAMES FROM AN ARROUTE GRAVITY SURVEY IN THE UNITED STATES

N. A. Zunberge, J. E. Faller (Joint Institute for Laboratory Astrophysics, University of Colorado and National Dureau of Standards, Boulder, Colorado, 80309) and J. Gachwind

Using the recently complated JilA absolute gravity meter, we made an absolute gravity survey which covered teelve sites in the Helted States. Over a period of eight weeks, the instrument was driven a total distance of nearly 20,000 be to sites in California, New Mexico, Colorado, Wyoming, Maryland and Massachusetts. The time spent in carrying out a measurement at a single location was typically one day. A measurement scouracy of around 1 x 10-7 m/s² (10 pgs) is believed to have been obtained at each of the sites. (Absolute gravity, acceleration of gravity, gravity, gravity, sand, pages, 190015.

Hydrology

J. Geophys. Res., Red. Paper 380936

CONTRICTIVE USE OF GROUND WATER AND SUPFACE HATER FOP IRRIGATED ARRICULTUPE: RISK AVERSION John D. Bradehoeft (U.S. Geological Survey, 345 Middlefleid Road, Monio Park, California, 34075) and comm D. Bradehoeft (U.S. Geological Survey, 345
Middlefield Road, Henio Parr, California, 94025) and
Robert A. Young (Department of Fooncaics, Colorado
State University, Fort Colling, Colorado, 8523)
In examining the South Platte system in Colorado
where surface water and ground water are used conjunctively for irrigation, we find the actual installed
well capacity is approximately sufficient to irrigate
the entire area. This would appear to be an over
investment in well capacity. In this paper we examine
to what extent ground water is being developed as
inausance against periods of low streamflow.

Using a simulation model which complex the hydrology
of a conjunctive stream aquifar system to a behavioraleconosic model which incorporates Parmer behavior in
such a system, we have investigated the economics of an
area patterned efter a reach of the South Platte Valley
in Colorado. The results suggest that under current
economic conditions the most reasonable ground-water
pumping capacity is a total capacity capable of
irrigating the available surveys with ground water.
Installing sufficient well capacity to irrigate all
available acreege has two benefits: (1) this capacity
maximizes the expected nat heavifus in immuse income;
it reduces the variance to essentially sero.

As pumping capacity is installed in a conjunctive use
system the value of flow forecasts is disminished. Poor
forecasts are obsepanated for by pasping ground water.

Metar Resour. Res., Paper 19051

JIIO droundwater
TRANSPORT OF REACTING SCALITES IN PORCOS MEDIA: RELATION
SETURES HAMMENATICAL NATURE OF PROBLEM FORWLATOR AND
CREMICAL, MAJURE OF REACTINGS
Jeoch Bishs (D. S. Goological Survey, Menio Park,
California, 94025)
Examples involving all broad reaction classes show
that the nature of transport—affecting chamistry may
have a profound "affect on the mathematical character."
Of solute-transport problem forwintation, Substantive
mathematical diversity among such forgolations is
throught about principally by reaction properties
adjob detection Mathem. (1) the resolution can be
frequenced as controlled by local challed formitted.

of whether it must be conditional as being correled by kinetics; (2) the reaction is homogeneous of heterogeneous (3) the reaction is a series of reterogeneous (3) the reaction is a series reserving the homogeneous continuity. These properties to the characteristic of the reserving as well as the choice of the resent to describe the stipulate, for instances: (1) the type of chemical continues of the reserving the continues of the reserving terms and continues about the relations needed to characteristical framformations needed to characteristical transformations needed to characteristic or which indice quantions into operational orse. These and other influences determine such astematics features of problem-framilitions, as the rature of congruences of transport only all differential, nimultaneous equations, but the involves algobiance, partial-differential, involvences equations, but the condition of the beauty or resolved. Exploration of the reaction of the beauty or resolved. Exploration of the reaction of the operations of the transport enthreatics of the reactions chemical relation (i.e. equilibrium or acquaitions, foliute transport, chemical reaction, or one reality or only only or one reality. Water Rusour, Ros., Poper 3W09b2

3160 Runoff and Streamfle CONOMIC EVALUATION OF WATER HARVESTING IN MICHO-

COMMIL EVALUATION OF WATER HARVESTING IN MICE-CATCURENTS
G. Gron (Bon-Gurion University of the Megar, Jacob Blaustein Institute for Basert Research, Kiryat Schooker B4990, Israel), J. Bon-Asher, A. Issar and Th.M. Boers
A cost-benefit analysis of the micro-catchrant-water-harvasting (MCMH) technique has shown that is highly dry zone (i.a. annual precipitation of less than 150 mm) the predicted income is negative. The introduction of modified technology improved water-harvesting and thus increased the predicted net kmr. These modifications are associated with additional expenses leaving the additional benefit questionable. A cost-benefit analysis of MCMH with inserts (perforated vertical drainage pipes) to improve water use efficiency has led to a conclusion that not know is higher than that of MCMH without inserts, Mosner, in a highly dry zone the net income is still negative (although only slightly) while in dry zone (i.e. annual precipitation of 250 mm) it becomes positive. (Cost-benefit, nicro-catchwent, inserts, runoff efficiency).

3160 Runoff and streamflow STOCHASTIC STREAMFLOW MODELS FOR HYDROELECTION STOCHASTIC STREAMFLOW MODELS FOR HYDROELECTIC
SYSTEMS
M.Y.F. Peraira, G.C. Oliveira, C.C.G. Costa P.
J. Kelman (Systams Departmant, CEPEL - Control of Pesquisas de Energia Eletrica, P.O. Box21)
This paper describes the development of a monthly streamflow model for the Brazilin this paper describes the development of a monthly streamflow model for the Brazilin disaggregation of lag-1 autoregrassive small flows into monthly values. Model feature include addition of new sites, non-parential include addition of new sites, non-parenty generation of monthly flows and correction of mogative values. A mathodology for asserging model adequacy is described and applied in Case study comparing the proposed model with multivariate monthly autoregrassive model. In economic effect of model salection is illustrated in a realistic generation planning case study it is shown that investment differences resulting from the application of different model; it reach USS 1 billion, (Stochastic hydrology hydroeloctric systema).

1160 Runoff and Strommile

ICONOMIC EVALUATION OF MATER HARVESTING IN MICOCATCHMENTS
G. Oron (Ban-Gurson University of the Negev, Jacob
Blaustein Institute for Desert Research, Kiryst SalBoker 0-1990, Israel), J. Ben-Ather, A. Issar and
Th.M. Boers
A cost-benefit analysis of the micro-calchrestmater-harvesting (MCMI) technique has shown that in
highly dry zono (i.e. annual precipitation of less
than 150 mm) the predicted income is negative. The
introduction of modified technology improved water
harvesting and thus increased the predicted nat finalThose modifications are associated with additional
expenses leaving the additional benefit questionable.
A cost-benefit analysis of MCMH with inserts
(perforated vertical drainage pipes) to improve water
use efficiency has lad to a conclusion that met isser
is higher than that of MCMH without inserts. However,
in a highly dry zono the not income is still negative
(although only slightly) while in dry zons (i.e.
annual precipitation of 250 mm) it becomes positive.
(Cost-benefit, micro-catchment, inserts, runoff
officiency).
Mater Renour. Ren., Paper 190972

1199 General (Small Reservoirs)
Ol'TIMUM DESIGN OF SMALL RESERVOIRS (TANKS)
O. J. Holweg (Department of Civil Engineering University of California, Davis, California, 95616), P. N. Shama Small reservoirs, called tasks, are a part of tuducing and many other countries. Though considerable interests is being planned to construct more of them, so interests is being planned to construct more of them, so interests is being planned to discover the most efficient design distants. This paper proposes a nonlinear optimizates and tanks. This paper proposes a nonlinear optimizates and technology of because a traditional approach is combined at technology of because a traditional approach is combined intensive or high technology construction methods. Intigists watersupply, optimization, tanks).

Meteorology

3715 Chemical composition and chemical interactions ON THE TEMPORAL INCREASE OF TROPOSPHERIC CN-O.W. Ethal & [Institut Für Atmosphärische Chemic Merschungsanlage Jülich GmbH. Postfach 1913, 0-1/0 Jülich, FRO), R.J. Zandar, and R.A. Lamontagne The available data on the trapospheric Ch. aping ratio in the Northern Hemisphera are exemined for a possible trand - with the following result: There was no or little increase between 1948 and 1965 as released for a little increase between 1948 and 1965 as released by IR measurements of the atmospheric Ch. column destroy. The surface of the column destroy of the state of the crease in tropospheric Ch. at an average rate of sheet crease in tropospheric Ch. at an average rate of sheet crease in tropospheric Ch. at an average laboralored. I to 2 %/yr has been observed by several laboralored. The overall trend resulting for the past 30 years in the post of the surface of t J. Geophys, Res., Green, Paper 300339.

3713 Chemical composition and chemical interastion ON THE VARIABILITY OF ATMOSPHERIC CARBON BIGGIES. CONCENTRATION AT ARROSP, MARKE DURING WHITE B. Halter (Cooperative Institute for Research in Environmental Sciences, Campus Box 449, University of Colorado, Requiser, CO 80309) and J. M. Barzis Winter variability over periods of 1 to 5 days to Winter variability over periods of 1 to 5 days to Winter variability over periods of 1 to 5 days to winter CO; doncentration at Earrow, Alaska was studied by anamining the relation between CD; noncentration at the surface control of the second with relatively deep market-based tration occurred with relatively deep market-based tration occurred with relatively deep market-based tration of these ear manages is qualitatively acquisity with both a matural CO; source, such as the Amilia. Arctic air consea. The long residence than the Arctic of these air hanses is qualitatively complished. Arctic of these air hanses is qualitatively complished to the consent of the consen 315 Chesical Composition and themical interactions on The TEMPORAL INCREASE OF IROPOSPHERIC CH.

JM. Enhalt (Institut für Atmospherische Chemie, kernforschungsanlage Julich GmbH, Postfach [913, D-5170
forschungsanlage Julich GmbH, Postfach [91], D-5170
forschungsanlage Julich GmbH, Postfach GmbH,

, Geophys. Res., Green, Paper 300339

NAME DESCRIPTION OF THE PROPOSITION OF THE PROPOSIT

District of Florids, Gainevilla, FL 32611, M.A. Chemestry of Florids, Gainevilla, FL 32611, M.A. Chemestry bas been measured photographically as a function of height and time for graphically as a function of height and time for even subsequent return attreas in two lightning lisses at caugas of 7.8 and 8.7 km. The film used was foods 4478 Shellburst which has a roughly constant spatial resolution was about 4 m. The observed light signals consist of a fast rise to peak followed by a flows decrease to a relatively constant value. The applieds of the initial light pask decreases exponentially with height with a decay constant of about 0.5 to 0.8 km. The 20 to 80 percent rise time of the hitial light signal is between 1 and 4 uses near ground and increases by an additional 1 to 2 used by the time the return stroke reaches the cloud base, a hight between 1 and 2 km. The light intensity 30 isso after the initial peak is relatively constant with height and has an amplitude that is 13 to 30 percent of the initial peak at aloud base. The logarithm of the peak light intensity wear the ground is roughly proportional to the initial peak settic field intensity, and this in turn implies that the current decrease with height may be much slows than the light decrease. The absolute light latensity has been estimated by integrating the photographic signals from individual channel segments to simulate the calibrated sil—sky photoelectric data 40 m and Kridet (1982). Using this method, we find the mean peak radience mean the ground is 8.3 x 10 M/m, with a total range from 1.4 x 10 to 1.5 x 10 M/m.

ophys. Re., Green, Paper 300602

1799 General (Atmospheric measurements)
DR ATMOSPHERIC LIFETIME EXPERIMENT, IV: RESULTS FOR
CJCL3 BASED DR TABEE YEARS DATA
D.R. (unmoid (Schubil of Geophysical Sciences, Georgia
Institute of Technology, Atlanta, Georgia and CAP,
Incorporated, Atlanta, Georgia), R.G. Prinn, R.A.
Jarussen, P.G. Simmonds, F.N. Alyea, C.A. Cardelino,
and A.J. Crawford
Resurements of the atmospheric concentrations of
CJCL2 at five remote sites by electron-capture gas
chorategraphy for July 1970-June 1981 are reported.
In January 1, 1980 the globally-averaged mixing ratio
of dichlorodifluoromethane in the lawer troposphere is
esticated to have been 285 pptv and to have been
increasing at 6.01/year. Assuming destruction of
CJCL2 in the stratosphere only, its atmospheric lifetra is estimated by the inventory technique to be 69
pars. However, using trend analysis the lifetime is
estimated to be longer than 81 years. The observations
toysest a need to further assess the atmospheric
miesse of CJCL2, particularly that in Eastern Europe.
J. Geophys. Res., Green, Paper 1,00670

Oceanography

TA Boundary Layer and Enchange Processes

(ASPARISM OF OBSERVED AND GENETROPHICALLY CALCULATED

DESPINE SURFACE WINDS OVER THE EAST CHINA SEA

1. Reich and Richard D. Romes (Oceanography Department,

Reich State University, Tellahassee, Florida 12:06)

Entertine geostrophic winds (V_g), calculated over

Us Test China See From surface prossure maps are com
just to observed winds (V_g) from the region. For mean

yield, the average counterciockwise weering angle from

yield, the average counterciockwise weering angle from

yield, the average counterciockwise veering angle from

yield, the 179 and the average reduction in amplitude

is 1816. For fluctuating winds the average veering

cit streamblion are 25° and 55%. The greatest reduc
tion occurs for land stations while the lowest 137%;

there is an offshore buoy station. Evidence from

for cases where observed Ginds are of such lower

capitude and do not appear to be reliable. (Over
test where observed Ginds are of such lower

capitude, sarine boundary layer).

J. Geophys, Ras., Green, Paper 100951 J. Coopbys. Rms., Green, Paper 300951

4710 Chemical Oceanography (Calcium Carbonate)
CENICAL ACCUMILATION VARIATIONS UNDER THE PERU CORREST
UNION THE PAST 130,000 YEARS
1.A. Boyle (Department of Earth and Floretary Sciences,
Bassachusets Institute of Tochnology, Cambridge,
A. 02139)

Solid THE Past 110,000 YEARS

LA, Boyle (Department of Earth and Flonetery Sciences, Essanbussis Institute to Technology, Cambridge, Marchanett Institute of Technology, Cambridge, Marchanett Institute of Technology, Cambridge, Marchanett Constitution and the Institution of Marchanettic Institution which alter the mean grain size of meditactical time and the Institutions which alter the mean grain size of meditactical time and the Institutions which alter the mean grain size of meditactical time and the Institution which alter the mean grain size of meditactical time recombination rate and Ti/A1, metablished from accumulation rates are thosely related to the consultation the Inverted to compute a high-resolution rates are closely related to the oxygen Loctope stord in the core, with a phese leg and damping content that is compatible with the response time of calcing cannot be in the core, with a phese leg and damping content that is compatible with the response time of this size responds to several processes independently interested with climatic change. The relative still size responds to several processes independently interested with climatic change. The relative size and other lines of avidences 15% of the Increased constrained by the resord is this core and other lines of avidences 15% of the Increased constrained productivity decreases in desired and the constrained MADE formation; its four to carbonate size, and the residual 50% and the constrained with climatic and the residual 50% and the carbonate size, and the residual 50% and the carbonate and constrained who hover a constrained with the cannot size, and the residual 50% when the constrained and the constrained with climatic and and the residual 50% and the carbonate and constrained with climatic changes. carbana are consistent with observations on Alamborithme consistent with the North Atlantic. With the second properties are variations correlate with the second of colian quartz deposition near iteratory. Artica, and in a general way, with the climatic record, iteratically from the organ isotops record, and may produce independent wyidenes on the nature of climate (itemium, climata, Para current)

J. Geophys. The., Draw. Pers. Montal. J. Geophys, Res., Green, Paper 300937

Til Circulation (Continental Siope)
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To the Circulation of the Continental Siope
Soot Sole, Assesshweets, C2543), and P-T. Shaw
Wast-botton currents over the mid-continental slope
The Continental shalf, allowing the settling out of fine
the continental shalf, allowing the settling out of fine
settless and their incorporation into permanent
personnel of the Continental Siope of the
Continental Special Continental Siope (Continental Siope)
The Continental Siope (Cont 1. Gaophys. Res., Green, Paper SCIGDS

4765 Surface Waves
'LAYOVER' IN SATELLITE PADAF LYAGES OF OCEAN WAVES
J.F.S. Cover, linetiture of Ocean Sciences,
J.P.S. Cover, linetiture of Ocean Sciences,
J.P. Cover, linetiture of Ocean Sciences,
Present accels explaining radar imaging of ocean
surface waves have considered variations in radar
cross section of the child or roughead surface, and
velocity bunching effects caused by the dopplar shifts
of moving scatterers, it is pointed out here that
aiople 'layour' effects will cause an additional,
aignificant modulation of the image brightness that
increases the visibility of range-traveling waves,
(Parote sensing, radar, surface waves).

J. Goophya, Ros., Green, Rema, Nobel J. Geophys. Ros., Green, Paper JC0982

A780 Underwater Sound
ON THE REMOTE ACOUSTIC DETECTION OF SUSPENDED SEDIMENT
AT LONG MAYSLEADGITS
Alox E. Hay (Department of Physica and HewCoundland
Institute of Cold Ocean Science, Hamorial University of
Newfoundland, St. John's, Seaf-quadland Alb 387)
Experimental results are presented which indicate a
linear ratarion between the Line-averaged amplitude of
the savelope of the backcattered acoustic pulse at
192 kHz and the square toot of suspended sediment concentraction in the 10 to 100 mg t'l range. Particle sixes
ranged from 2 to 140 km. The measurements wate made in
a negatively buoyant, mine tailing discherge plume in a
submarine channel at depths of 60 to 90 m in Rupart Iniet, B.C. From the theory of acoustic backscatter from
a solid stastic sphere in the Rayleigh ragion it is
shown that if the pressure amplitude of the backscattered wave is Rayleigh distributed, then such a linear
relation is to be aspected. Expressions for the options
acoustic frequency for the dataction of dilute suspensions at a given range and for the studium datactable
concentration are obtained assuming a themal noise background. The possibility that bubbles contribute to the
backscatter is considered and found to be unlikely on
the basis of probable bubble lifetimes.
J. Geophys. Res., Green, Faper 100350

ATS9 Conormi (Bubble Persistence)
THE PERSISTENCE OF AIR BUBBLES AT A SEAMATER SURFACE
Scott R. Burger and Dungan C. Blancherd (Attrospheric
Boiences Resmarch Center, Beats University of New York
at Albuny, Albuny, NY 19222)
The time an air bubble persists at a seawater
surface is a function of many factors, including the
relative hundrid and speed of the air over the surface
of the water. We find that bubble surface life
increases in wagnitude with decreasing bundlity and
increasing speed of the air. This appears to be caused
by a salinity gradient along the bubble cap. This produces a surface toneion gradient (Marangoni affect)
that increases bubble surface life.
J. Geophys. Res., Papar 100918

Particles and Fields— Interplanetary Space

5310 General (Cutoff Rigidity Variations)
THE EFFECT OF LOCAL PERTURBATIONS OF THE GEOMAGNETIC
FIELD ON COSMIC RAY CUTOFF RIGIDITIES AT JUNGFRAUJOCO

THE EFFECT OF LOCAL PERTURBATIONS OF THE GEOMAGNETIC FIELD ON COSMIC RAY CUTOFF RIGIDITIES AT JUNGFHAUJOCH AND NIEL.

E.O. Flückiger, D.F. Smart and M.A. Shea (Air Force Geophysics Laboratory, Hanson AFB, MA 01/31)

He have investigated the effect of local perturbations of the geomagnetic field on the vertical cosmic ray cutoff rigidities at Jungfraujoch and Kiel as representative ridilatitude neutron monitor stations. The main, effective, and Stormar vertical cutoff rigidities and their changes were determined by utilizing the trajectory-tracing technique in a magnetic field which is rodeled as a simple dipole field to which the disturbance field is superposed. It was found that the cosmic ray cutoff rigidities are nost sensitive to variations of the z-corponent of the geomagnetic field at equagnatic latitudes -20°C A v 30° and at longitudes within 90° to the east of these morthern healsphere stations. Furthernore, cutoff rigidity variations at kiel are predominantly due to changes of the geomagnetic field within geocentric distances 2.5°C, c °C or or caused almost ecclusively by magnetic disturbances within 1°C or < 4.5°C, c or component of the rain of the rain of the radial, latitudinal and longitudinal structure of the raquetic parturbations is given explicitly. The results are discoused with respect to the theory by Treinsn (1953) describing the effect of a ring current on cosmic ray cutoff rigidities. It is also shown that for the analysis of the characteristic properties of the correlation between cutoff rigidity variations and specific quoragnetic perturbations the rigidity variations and specific quoragnetic perturbations the rigidity corresponding to the first "discontinuity band" of the rigidity specific according the second of the pagnetic storms).

J. Goophya. Roe., Blue, Paper 3A0919

J. Goophys. Rus., Blue, Paper 3A6919

Particles and Fields— Ionosphere

5530 High-latitude ionospharte currents
EQUIVALENT IONOSPHERIC CURRENT SYSTEMS REPRESENTING
LUMAR DAILY VARIATIONS OF THE POLAR GEOMAGNETIC FIRID
S. Marsuchitz (High Altitude Observatory, NCAR, Boulder,
Colorado 50307) and N.-Y. Xu

Equivalent lonospheric current systems of the lumar
daily geomagnatic data for three seasons and the yearly
average. Clear convective currents at high latitudes
are found in addition to the wellknown mid-low latitudes
are found in addition to the wellknown mid-low latitude
current system. Field-sligned electric currents as well
as the wind dynamo effects which produce the obtained
electric current systems for the semidiurnal variation
are eramined. It is concluded that the wind dynamo
plays a busic role in producing the current system at
high latitudes, since lumar offects on the fieldsligned current distribution are difficult to explain.
(Gurrant systems, field-sligned electric currents, wind
dynamo effects).

J. Geophys. Res., Blue, Paper 3A0904

J. Geophys, Res., Blue, Paper 3A0904

5530 High-latitude Ionospheric currents SPATIAL RELATIONSHIP OF FIELD-ALIGNED CURRENTS, ELECTRON PRECEPTIATION, AND PLASMA CONVECTION IN

SPATIAL BELATIONSHIP OF FIELD-ALIGNER CUMBERTS, ELECTROR PRECIPITATION, AND PLASHA CONVECTION IN THE AURCHAL OVAL W. B. Coley (Center for Sps. Sai., Physics Prog., Univ. of Testan at Delias, Eitherdson, TE 73080) A tacknique has been developed that allows the nealysis of magnetomenter data from Atmosphere Explorer-C during those particle within the epiceersfi is spinning and eclipsed (not smilt). The etilization of those magnetometer magnetoments to datarraine field-aligned current structure in conjunction with energetic particle and please convection measurements from AE-C enables us to determine relationships between these phenomena in the mighttime surcest zone. From a study of some 18 surceral own. From a study of surceral own. From a surceral to surceral own. From a surceral from surceral surceral boundary in both the evening and moralus sectors. It is seen that the low conductivity in the winter poler che implies the absence of fisial-aligned currerals unthat region. The data indicate that the special currerals in the late evening and early worning sectors. If it is also closed fisial lines excending a striburd from the inser side of covertion, particle pracipitation.

the evening and morning sectors. It is seen that the
low conductivity in the winter poler cap implies the
absence of field-aligaed corrents in the late
data indicate that the Region I currents in the late
data indicate that the Region I currents in the late
data indicate that the Region I currents in the late
lines extending serthward from the inner adja of the
ilmes extending serthward from the inner adja of the
magnetospheric boundary layer. (Currents, convection,
particle pracipitation).

J. Geophys. Res., Blue, Paper 140945

Seach Contential Capacity Contents of Convections
WITH MILLENGE MILL ORSENATIONS
WITH MILLENGE MILL ORSENATIONS
J. J. Evens, J. M. Hoir and E. M. Mand
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High-latitude ionsophers were compared with Milletone
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damsity region, a nightside midiatitude trough, and a region of slightly enhanced densities in the autoreal zone. Aithough the dawside high donsity region was due to solet EUV rediction; it was not symmetrical shout local noon (1000-1900) it secret of much to the offect of horizontal tramsport. The nightheide mid-latitudu trough was the despeat, the wideat, and reached its test squatorward institude in the norming socior. The codel was able to reproduce these two features quite accurately. In the duck soctor, the trough was filled in and its latitudinal extent was restricted by a discrete nurreal arc, a feature not included in the incosporate model. Except for this are region, the enhanced electron donation in the surreal zone wore adquartly described by the average practipitation liuxes used in the model. The observed plasma drift velocities were consistent with a stwo-call, asymmetric convection pattern with enhanced flow in the dusk sector. Outside the polar cap, the fall-off of the negationshort potential with latitude was proportional to the inverse of the sine of thistitude was proportional to the inverse of the sine of trilatitude table fourth power. The convection pattern explayed in the model included these features and had a OR to creapails—rcap potential. Efforts to reproduce the observed behavior using a larget cross-polar-cap potential (90ky) or a symmetric pattern are also presented. These ware generally less accessful and demonstrate the sensitivity of the marphology of the F-region at high lacitudes to the convection process.

3343 lonospheric disturbances
MODELING OF SPACED-RECEIVER SCINTILIATION
HARMURDURMS
A. W. Wersik (Department of Pleatrical Engineering, University of Illinois at Urbana-Champeign,
Urbana, Illinois, 61861), C. E. Liu and K. C. Teh
Spaced-receiver scintiliation measurements are
modeled applying scintiliation theory together
with codel mustral representations of nonsocial applying scintilistion theory together with codal spettral representations of non-frozen turbulent media. The effects of velocity distribution of scatterers, diffusion or irregularities and valocity gradient across the scattering layer on parameters derived from spaced-receiver scintilistion exporteness are studied. Both cortelation and dispersion smalyses are comeidered. The results from modaling are compared with observational data from the equatorial region. It will be demonstrated that self-consistent models can be constructed in interprating the data and information about the drift velocity field in the tocophery can be obtained from spaced-receiver experiments. (Spaced-receiver, scinniliation) Rad. Sci., Paper 350661

5545 Lunespheric disturbances COORDINATED MEASUREMENTS OF LOW-FRENCY ELECTRON PRECIPITATION AND SCINTILLATIONS/TFC IN THE

COMBINATED MEASUREMENTS OF LOW-FRENCY ELECTRON
PRECIPITATION AND SCINTILLATIONS/TEG IN THE
AURORAL OVAL
Summada Seru (Irmanual College, Bouton MA 02115),
Elieau MacKenzio, Santinay Bassu, MacC. Carlson,
D.A. Hardy, F.J. Rich, and R.C. Livingston
A case study of coordinated observations of lowenergy (1500 aV) between precipitation in the auroral
oval from MSF/F2 and phase and amplitude scintillutions from Gone Bay, mains a goostationary smutility
transmitting at 244 MHz, is presented. The procipitation event took place during the capassion phase of an
intense evening substorm, when the equatorward boundary of the diffuse aurora teached 59° invariant latitude. Particularly large phase scintillations told
radiums for fluctuation frequencies - 0.0007 Hr) warg
found to be well correlated with intense fluxes told
particles (car's strill of precipitated hor-energy
sloctrons. Total electron content and outpretometer
measurements indicate that the enset of the precipitation swent was about 10 min prior to the ICISF pans.
Mithin this time scale, the ionization generated in the
f-region could reach the topside so that the thermal
sensor on board the DMSP satellitte was able to because
a factor of 2-1 density enhancement at 800 km. The
lutitudinal width of these density structured in the
Chatamita. The gradient scale-length measured in tha
topside was only 30 km, which was probably responsible
for the fast growth rate of the scintillations
rate changed rather desertically compared to quiet magnetic class, become reached the company of the scintillation
rate changed rather desertically compared to quiet magnetic class, become reached the company of the scintillation
rate changed rather desertically compared to quiet magnetic class, become reached the combined phase scintillaton account of the combined phase scintillaton account of the combined phase scintillaton account of the account of the analysis of the scintillaton account of the combined phase scintillaton account of the account of the anal

5550 Airglow
DEPROMEKE OF AURORAL FUV EMISSIONS ON THE INCIDENT
ELECTRON SPECIAUM AND NEUTRAL ATMOSPRERE
D.J. Strickland (Bears Associates, Inc., Post Office
Box 2349, Reston, Virginis 27090), J.R. Jasperse and
J.A. Whalen.
In this paper we exacts the relationship among

In this paper we exacts the relationship among certain prominent auroral INV smission features, the incident electron spectrue, and the model neutral strosphere. Given the neutral atmosphere we show that for simple models of the incident electron spectrum (Maxwellian and Goussian in energy) matellite measurements of FVV emission features, in parinciple, determine the incident electron spectrum the tincident electron spectrum and the K-region plasma density profile for the continuous (diffuse) surper and for a stable arc. (FUV emissions, aurora, electron transport).

J. Geophys. Res., Blue, Paper 3A0370

556) Plasma motion, convection, or offculation
MUMERICAL SIGULATIONS OF COUNTERSTEENING PLASMAN AND
THEIR RELEVANCE TO UNTERPHISPERIC FLOWS

8. Singh (Canter for Arcompheric and Space Sciences,
Utah State University, Logan, Utah, 80322) R. W. Schunk
The collisionlams expansion of contraversaming planman has been southed by solving the salf-consistent set
of Vianov and Poinson equations in one-dimension. The
motivation for the study is to slutidate some of the
basic physical processes which may occur during the
initial relilling of deplaced flux tubes after a magnatic ators. The simulation geometry consisted of two,
high density, W - O' - sheeren plasmas (conjugate
ionosphereo) separated by a low density W - electron
plasma (espatorial plasmasphere). The temperal wolution of the expanding plasmas and the electrostatic
potential in the region between the two nources has the
following characteristics. The initially minor W ions
rapidly llow out of the soutce regions, creating coonteratressing density-shock fronts which propagate at
the Sagdase Wash number for impractact shocks
(N-1,6). Bowever, the shocks are preceded by sourgetic
forstunnt ions, which are the first to fill the 'squatorial' region. When the counteratressing ion-prosecie
shocks collide, the density in the equatorial region torial region. Much the counternament of the description abouts collide, the density in the equatorial ragion becomes certly a constant, twice the value of the density in the individual shocks. The electrostatic potential distribution from the source plauma to the mid-point of the expansion region displays an interesting feature. A patential bill forms mear the mid-point efter the arrival of the main density-shock fronts. This localized potontial bill plays an isportant role in the thereshization of the ion attends and may occup in the squatorial plaumasphera after magnetic accommands the counterstreaming plaumas act resurtably exable with respect to the ion-sequent instability, which is in agreement with the linear instability theory. Nowever, in the presence of a magnetic field, the linear instability theory predicts that the counterstreaming energetic forermous tous can excite explorerm warms, which is turn our thermalize and trap the energetic forexunstre. Such a mechanism say he operating in the equatorial pleasmaphere shortly after magnetic storms. J. Geophys. Hear., Else, Paper 3AD921 J. Geophys. Ror., Blue, Paper 3AD921

Particles and Fields— Magnetosphere

5715 Electric Fields
THE DISTRIBUTION OF AURORAL ELECTROSTATIC SHOCKS BELLOW BOOM AN ALTITUTE

E. I. Bennett Physics Department and Space Sciences Laboratory
University of California, Berkeley, California, 94720), M. Temerin, and J.

the control of California, Berkeley, California, 94720), M. Temerin, and F. S. Mozer

This paper examines the distributions and characteristics of electrostatic shocks as observed by the SL-J polar-orbiting satellite. There is auroral oval coverage by the satellite at all magnetic local times and at all elitudes between 240 and 8000 km. Electrostatic shocks are reasonably uniformly distributed in magnetic local time, with a slight increase in the probability of occurrence in the cure region and a decrease to the probability of occurrence in the cure region and a decrease in the population of the control of the con

J. Geophys. Ras., Blue, Paper 3A1014

5733 Magnetic storms MAGNETOSPERENC PROCESSES PRECEDING THE OWSEY OF AN ISOLATED SUBSTORM - A CASE STUDY OF THE MAECH 31, 1978

ISOLATED SUBSTORM - A CASE STUDY OF THE MARCH 31, 1976 SUBSTORM A. Mishids (Enstitute of Space and Astronautical Science, Komaha, Meguro, Tokyo 13, Japan) and Y. Kanide (KOAA/Space Environment Laboratory, 323 Broadway, Sculdar, Colorado, 80303)
We assained in detail the sifeor of a southward turning of the interplaneary magnetic field (INO) on the state of the magnetosphera, taking advantage of the availability of the date from IMS magnetomater maridian chains and from saveral spacecraft. A clear most rubitors occurred on March 31, 1978, when the magnetomater stations were located in the midnight to morning sector and the appeceraft were near the equatorial plane of the nightside magnetosphere. The const time of the substorm sepanation phase could be determined unsabiguously in terms of both ground-based magnetic end suroral signatures, and there was an interval leating and this onset. In this intervaling interval the innesher textern system of the DP 2 type developed. This enhancement of the loss spheric current is driven directly by the souler when the the symmetric transmission of the symmetric abstract that and the same of the programment of the symmetric and the same of the programment of the symmetric and the same of the programment of the symmetric and the same of the programment of the same part of the symmetry and the same of the programment of the same part of the programment o current is driven directly by the solar underagnetaphere coupling. The onset of the expansion phese was then associated with the decrease in the negmetic field energy develop in the tall, providing swidence that the substorm energy was supplied by the release (unleading) of energy from the tail. It is most likely that substorm energy dissipated in the success incomphere throughout this relatively isolated and simple event is supplied by two components, "directly driven," and 'loading-unloading', the relative importance of which wattes depending on the different substorm phases. (Substorm, ING effect, growth phase, unloading).

J. veophys. Fea., Blue, Paper 300918

5755 Plasma Instabilities 5770 Short-Period (Loss than 1 day) Verlations of Magnet's Fields
SATURN'S MAGNETOSPHERE: OBSERVATIONS OF ION CYCLOTPON WAYES NEAR THE DIONE L SMELL E. J. Smith (Jet Propulsion Laboratory, 4800 Cam Grove Drive, MS 169-506, Pasadema, California, 91109), 8. T.

J. weephys. Pes., Blue, Paper 3A0934

E. J. Seth (Jet Propulsion Laboratory, 4800 Get Grove Drive, MS 169-506, Pasadema, California, 91109), 8. T. Tsurutani
High time resolution (0.75 sec) measurements obtained by the Pionmer II Vector Helium Magnetometer inside Saturn's magnetosphere show quasi-periodic waves to be present near the Bione Lishell between L. 6.3 and 6.7. Although Bione was far fron the spacecraft, the waves were observed when Pioneer was both inbound to, and outbound from, periopsis and are presumably associated indirectly with Bione. The waves have a characteristic period of 18 sec. The waves were observed, the Pioneer II planta analyzer detected a peak plasma density associated with heavy ions presumably souttered fron Dione's surface and tentatively identified as 0°°. Subsequent Yayager observations in this inner torus appear to be consistent with 0°. The characteristic period of the waves is well below the proton gyropariod. Because the heavy ions are hot (-10° %), the Alivan phase speed and the ion thermal speeds are nearly the sene. Ion cyclotron resonance of the waves with the dominant ions appears Capable of generating the waves. Honoratical arguments besed on the growth rates of the waves suggest that 0°° to rore lifely to be responsible than 0° but that a resonance involving N° tons with energies of a few kev cannot be excluded. The existence of a pitch angle anisotropy after of the heavy ions by the waves should cause pracipitation with the possible production of sureres peaks.

J. Geophys. Res., Blue, Paper 3A0650

J. Goophys. Res., Blue, Paper JAN959

5775 Trapped Particles
WYMAGER OBSERVATIONS OF SATURNIAN 16N AND ELECTRON PHASE
SPACE DENSITIES

I. P. Armstrong (Department of Physics and Astronomy,
University of Kansas, Lewrence, Eansas 65045), M. T.
Parmssas, E. V. Bell, II, and S. M. Krimigle
Voyager I and I Low Energy Charged Particle (LECP) observations of 30 keV to 2 May electron and ion energy
spectra and angular distributions have been used to
calculate phase space densities as constant first and
sacond adiabatic invariants in the Saturnian amposts
sphere. The tesuits are generally commistent with toward radial diffusion from an external source. The deta
obtained also indicate as source of ione located within
the orbital distances of Inceledans capable of producing
10 to 40 May/Gauss ions as well as a source of electrone
at about 3.5 Mg which produces particles at 100 to 200
May/Gauss. Higher segmetic moment (200-400 MeV/Gauss)
ions outed from the segmetic moment (200-400 MeV/Gauss)
ions outed from the segmetic soment (200-400 MeV/Gauss)
diffusion of these particles from a source of low (10 to
200 MeV/Gauss) magnatic moment particles deep in the
Saturalian magnatosphere is a new result of this work,
Eaveral smalyses of the observed phase space densities
in terms of time-independent radial diffusion are pre-

Saturnian magnetosphere is a new result of this work, Saveral malyaes of the observed phase space despities

J. Goophys. Res., Nive, Paper 180944

5775 Trapped Particles
ABSORPTION OF EXEMPTIC PROTONS BY SATURN'S RING O
Asses A. Van Alles (Physics and Astronous Department,
The University of Lows, Ioba City, Ione 25242)

A restudy has been made of Figure 11 data on the
distribution of sacragatic protons E, 2 60 MeV in
Saturn's inner nugnetosphers. An improved value of the
ratio of the Grand course strength B to the radial diffusion coefficient D is 6.9 × 10-14 cg⁻³ at r ~ 2.67 Bg
(1 Bg = Saturn's squatorial radius ~ 60,000 ks). Using
the recently calculated lower limit on 3 by Blake et
al., one finds an upper limit on the mean residence
ties T against diffusion b, 5 × 10² a (15 years) in the
major peak of the distribution, whereas using our
astrict estimate of B, one finds T ~ 2.2 × 10³ s (17.0
years). The two corresponding determinations of D are
3 1.3 × 10-11 and ~ 2.8 × 10⁻¹² R ² repentively.
A generous upper limit on D is 2 10-16 R ² s (1.0
years) the two corresponding determinations of D are
5 1.3 × 10-11 and ~ 2.8 × 10⁻¹⁸ R ² repentively.
A generous upper limit on D is 2 10-16 R ² s (1.0
years) the two corresponding determinations of D are
5 1.3 × 10-19 and ~ 2.8 × 10⁻¹⁸ R ² repentively.
A generous upper limit on D is 2 10-16 R ² s (1.0
years) the two states matter in Ring G is < 1.1 × 10⁻¹⁸ s (2.1) × 10⁻¹⁹ s (1.1) years) corresponding to the two choless of B. Then, using the
Yoyager data on normal optical equatity n ~ 3 × 10⁻⁵ and
on radial width for ~ 500 ks, one finds that the particulate in Ring G have an effective modius R >
0.035 ch, as areal mass density s > 1.8 × 10⁻³ g x 2. It is
untilized that he recedes 0.1 cm. The furgoring valued
of R (for shimmed apperion) particulates of where the
years (2 d and the distribution of vises where the
years (2 d and the distribution of vises where the
years (2 d and the distribution of vises where the
years (3 d and out that he has then 10⁻² of the specify.
The man radius of Ring 0 tag for the order of a kilometer or
larger a J. Geophys. Pps., Blub, Paper 3A0907

The second second second